Ontario

Ministry of
Transportation and
Communications

CURRENT TRENDS

IN

MAJOR TELECOMMUNICATIONS TECHNOLOGIES

Prepared for:
Communications Division
September 1984

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IN

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Carrier Policy and Research Office
Communications Division
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ACKNOWLEDGEMENTS

Like this one, any report of a broad scope and on the subject of complex technologies draws on material and resources from a vast number of areas. This report has been prepared by Stephen Merdzan under the supervision of Tedy Singh for the Carrier Policy and Research Office of this Division. Many staff of the Division have contributed in the preparation of this report. We are particularly grateful to Peter Foster, Lamberto Gomes, Allan Coates, Vivek Burhanpurkar, and Jim Kreppner for their valuable contributions through many discussions.

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August 1984

EXECUTIVE SUMMARY

Telecommunications is one of the fastest growing and constantly changing technologies today. It is a dynamic industry whose participants are constantly developing new products and fields of endeavour. The purpose of this report is to research the trends in the technological and market development in cellular mobile radio, fibre optics, satellites, local area networks and office automation. Findings with respect to each technology are summed up below.

CELLULAR MOBILE RADIO

Cellular Mobile Radio (CMR) technology is developing to basically fill a need among business users requiring mobile communications. Inadequacies in the current system have led to the development of CMR technology which employs low power radio transmitters and division of a geographic area into sectors or cells in order to facilitate channel multiplication. The CMR system allows greater capacity and efficiency than the present mobile communications systems.

CMR operation in Canada is expected to begin July 1, 1985. The market structure has been established by the federal government to be in the form of a duopoly operation. In each region, the only two participants will be Cantel, and the telephone company operating in the region.

CMR systems are currently in operation in numerous large U.S. cities and a Nordic CMR system has been in operation in several Scandinavian countries for more than a year. CMR technology has tremendous potential for growth in both Canada and the U.S. and its operation thus far seems to substantiate that fact.

LOCAL AREA NETWORKS (LAN's)

The networking of devices is not a new concept in itself; however, local area networks are a new application of old networking principles that allows increased operating efficiency in offices. One working definition of a LAN is, "An inexpensive digital system connecting dissimilar computers and other peripherals in a small geographic area, either various desks in an office, floors in a building, or buildings on a campus."

LANs increase office effectiveness and productivity through more effective use of shared resources. Different LAN architectures and topologies can be configured to suit particular office environments. LAN's are increasingly being implemented.

FIBRE OPTICS

Fibre optics technology is advancing rapidly today. The use of glass fibre optic cable, as thick as a human hair in communication networks, is enabling tremendous gains in efficiency and cost effectiveness. This is due to the low cost of the fibre and its incredibly large capacity for information transmission.

The use of optical fibre is a new development in information transmission. In the past, information has been carried predominantly by current travelling through copper wires; however, with fibre technology, it is carried by light pulses travelling through glass.

This type of transmission is immune to much of the interference and noise that plagues conventional copper wire circuits and signal preservation is such that the distance between facilities required to regenerate the signal (repeaters) has been increasing. Splicing is a major problem with optical fibre networks since proper alignment of the hair-thin fibre is critical.

Fibre optic communications networks are being implemented in Ontario, Quebec, Alberta and Saskatchewan, and all the telcos are increasing the fibre usage in their networks.

SATELLITES

Communications satellites, since their beginning in 1962, have remained an important facility for long distance communication. In fact, the number of satellite dishes in Canada and the U.S. has rapidly grown over the past several years. This has been due to a consumer desire to view a greater number of programs and without having to pay extra charges.

Systems designed to cater specifically to home satellite users are known as Direct Broadcast Satellite (DBS) systems and they generally employ smaller dishes, operate at higher power levels, and different uplink and downlink frequencies from conventional satellite systems. "True" or "high-power" DBS systems, however, would cost a lot more than conventional satellite systems and it is doubtful whether there is enough market to support the massive expenditures required to build and operate high-power DBS.

Mobile satellite (MSAT) systems are also of great interest. These systems would provide mobile communications over a large area and allow people to maintain communications while moving (e.g. from a ship). A Canadian MSAT demonstration system is to be developed and implemented by 1988.

Office Automation

Office Automation has been studied with a great deal of interest since it represents a major step towards the establishment of an information-based society. Its advancement is fueled by the need to increase productivity in the offices in order to maintain economic stability and remain competitive on a global basis.

Several technologies are contributing to automated office proliferation, for example, networking integrated systems and the increased power and versatility of today's microcomputer. Networking integrated systems is considered under local area networks; however, the evolution of the microcomputer and its accompanying technologies provide considerable information relevant to office automation. Microcomputer office systems available today are much more powerful than earlier versions and, in many cases, their ease and specificity of use is remarkable. The integration allows rapid assimilation and dissemination of data through the use of electronic means, thereby reducing the voluminous paper flow that accompanies traditional office environments.

These systems are primarily designed to promote better utilization of time, however, they have other benefits. Teleconferencing provides a means for effective long distance business communication without undertaking extended travel. Audio systems, full motion video systems and audio systems with graphics transmission capabilities are three types of systems that are available.

The increased use of microcomputers is causing the computers themselves to change. Todays models are faster, have more memory and can be used in a far greater number of applications due to the large quantity of available software. Microcomputers are also becoming much easier to use thereby allowing people of unrelated backgrounds to benefit from their use without having to become computer specialists.

INTRODUCTION

The purpose of this report is to investigate major technologies in the telecommunications industry today and to examine the trends to identify the direction of technology tomorrow.

The report covers five areas of technology: cellular mobile radio, fibre optics, satellites, local area networks and office automation. It is of a modular format; each section is self-contained and can be read individually or as part of the overall report. The sections assume very little background knowledge and generally start off with an introduction to the topic, develop the main ideas, and conclude with current status of the technology. The sections are written without much technical jargon in order to improve clarity and understanding.

The sources drawn upon for this report consist predominantly of journal articles both technical and otherwise, newspaper articles, and various government reports and studies. The sources are current, usually from 1983 to 1984, and are as varied as possible. The bibliography at the end of the report is also organized in a modular fashion following the format of the report.

1.0 CELLULAR MOBILE RADIO

1.1 Background

"Mobile radio telephone systems already exist in Canada but, except in their most rudimentary form, they do not share any common technology nor provide a uniform grade of service. Various systems exist in various provinces but, because of the different radio frequency bands utilized, as well as the differences in system protocols, subscribers find themselves isolated to a given geographic service area. The only system that permits portability is the technically archaic, operator assisted, mobile radio service that tends to be excessively loaded in urban areas and thus provides a low level of service availability."[1]

One contributor to the low level service is the congestion that occurs in the current system. For example, during peak periods, it can take thirty minutes or more in urban areas to obtain access to a free radio channel. Existing public mobile radio telephone (MRT) systems operate in the 150 and 450 MHz bands of the spectrum and have a limited number of available frequencies that can be assigned to the users. It is this limitation that causes congestion since there are often more users in relation to the channels available. Cellular Mobile Radio (CMR) alleviates this problem by employing a frequency re-use methodology through the use of cellular configurations.

"The telcos see the emerging cellular radio technology as an opportunity to introduce a high quality, uniform, mobile radio telephone service across Canada that would also be usable when travelling in the United States. Because of the

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1. George, D.L. et al., Cellular Radio in Canada: An Industry Analysis Project; unpublished thesis, University of Toronto, April 1984, Page 10 (Quoted with permission).

substantial capital costs of the system, and its high capacity, Cellular Radio services are directed at the urban market.

"In the United States, cellular mobile telephone services were first proposed to the Federal Communications Commission (FCC) by the telcos as a solution to the long waiting list for mobile telephone service and as a logical extension of the switched telephone networks. The typically small and independent RCC's indicated that the introduction of these improved mobile radio telephone services could destroy their business base. They petitioned the FCC to permit their participation in the development of cellular mobile radio services. The FCC agreed to split the assigned radio frequency band in two, giving half of it to the telephone system operators and the other half to a selected private licensee in the same urban area."[2]

In Canada, the Department of Communications (DOC) elected to follow the United States example to assign two licensees to operate in each area. The department also indicated that it hoped, as a byproduct of this initiative, to develop another exportable telecommunications capability in terms of both system hardware and system engineering.

1.2 Technical Viewpoint

There are three operating principles which differentiate the CMR from the MRT systems.

The first principle is low power transmission for CMR. In MRT systems, a high power transmitter is usually used to

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2. Ibid Page 10.

cover a large geographic area; however, with the CMR approach, low power transmitters are used to serve a small geographic area known as a cell. These cells are the second distinguishing feature of the CMR (hence the name Cellular Mobile Radio). An area to be served by the CMR system is divided into small cells (or sectors) which can be considered analagous to a honeycomb type of architecture (see Exhibit 1.1). It is through the use of these cells that the third, and perhaps most attractive feature of CMR, namely frequency reuse, is brought about.

For example, if frequencies of 800-805 MHz are assigned to one particular cell and, 806-810 MHz in a contiguous cell, then the next cell away may re-use 800-805 MHz. The frequency re-use or multiplication, allows for a considerable expansion of the number of channels available for users. This is very useful since a large number of simultaneous mobile calls can be served in the same area.

Densely populated areas with a large number of car telephone subscribers might have cells with ranges of less than eight kilometers. In less populated areas, the range could be 20 to 30 km. Base radio stations serve each cell and transmit, receive and control the radio signals to and from the mobile subscribers when a telephone call is underway. When a subscriber moves out of one cell into another while a mobile telephone conversation is in progress, the base station automatically allocates a new frequency in the new cell with only a split second interruption undetectable by the user. The cellular mobile switch is connected to the public network and to the base radio stations serving the cells. This links the mobile subscribers to the regular public telephone network, allowing access to any telephone around the world.

CELLULAR RADIO NETWORK

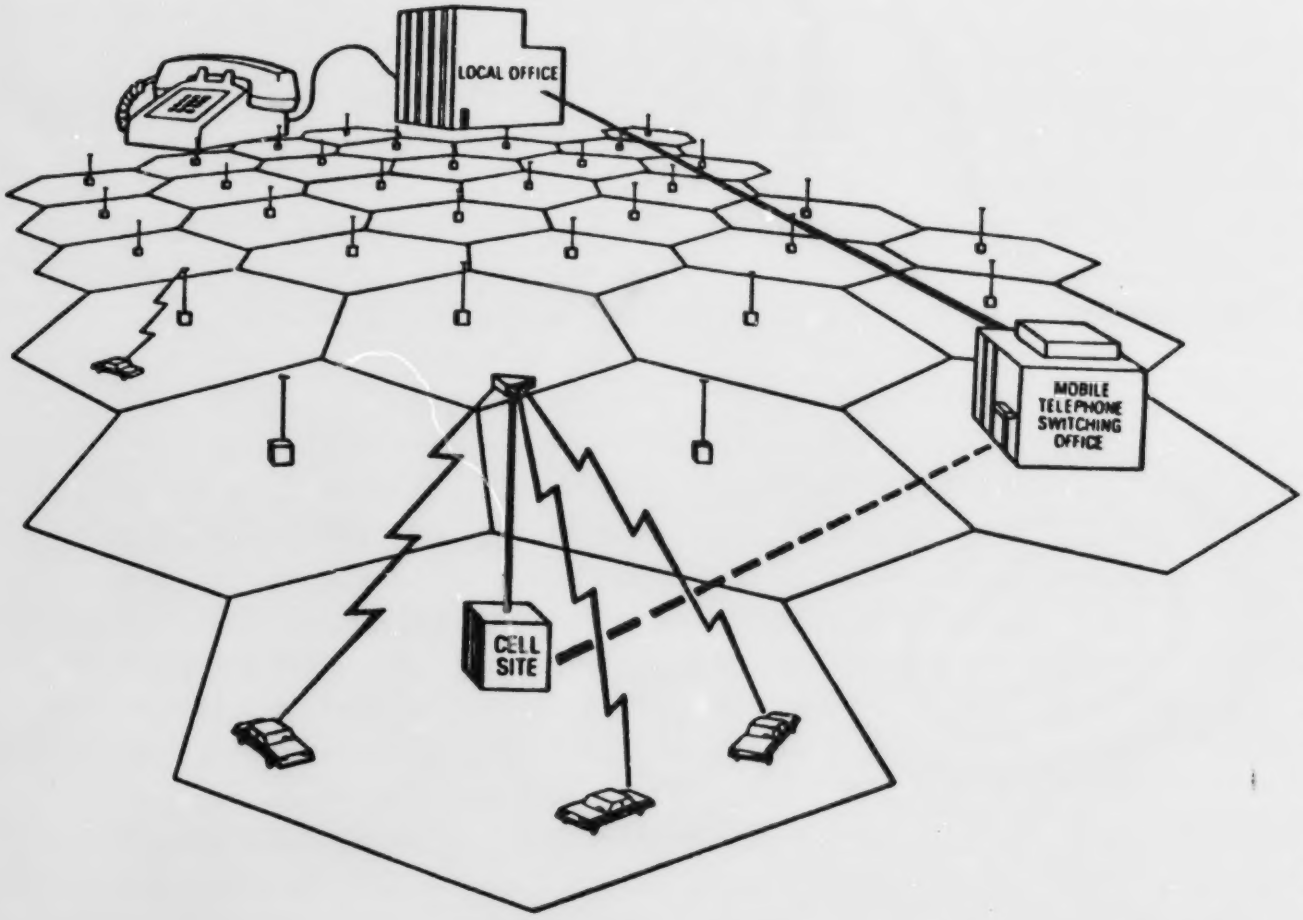


EXHIBIT 1.1

1.3 Cellular Radio Markets

In October 1983, the federal Department of Communications issued a notice for licence applications to provide cellular public mobile telephone service to 23 metropolitan areas across Canada. Each market is open to two licensees, one of which is the local telephone company. The organization that won the contract for all 23 centres is a Canadian firm, Cantel, that is backed by First City Financial Corp., Telemedia Inc., Rogers Telecommunications, Time Cellular Inc. of Ottawa and Celtel Ltd. of Hamilton. Cantel's operating system is the Aurora 800 Cellular Radio System which is manufactured by Novatel, a company jointly operated by Nova Corp. and Alberta Government Telephone. The DOC has split the bandwidth such that Cantel will use the 825-835 and 870-880 MHz blocks while the common carriers will use 835-845 MHz (mobile transmit frequency) and 880-890 MHz (base station transmit frequency).

In considering the Canadian market, the aim of this duopoly is to provide some competition and an improved mobile telephone service. However, establishing a firm cellular radio market in Canada, would also serve as a powerful marketing tool for the attraction of an international market thereby furthering Canadian industry and establishing Canadian technology at the forefront of the international cellular radio market. This would have many benefits such as improvement in mobile radio telephone service and job creation in skilled and high tech areas, not to mention furthering the presence of Canadian technical expertise abroad.

Cellular radio is not an untested concept even though it is just being introduced. The Nordic CMR System which is now operating in Sweden, Norway, Denmark and Finland has grown to 30,000 subscribers in the sixteen months since the beginning of the program. In the U.S., Hertz and Budget car rental companies now offer cellular radios on several of their luxury cars (about 100 cars total) in Chicago, Indiannapolis and Washington and expansion to 25 cities is planned by the year end.

Currently, Northern Telecom (NT) and General Electric (GE) are testing a system in Jacksonville, Florida which will serve as a prototype for their CMR systems in the U.S. and Canada. The test site was established as a result of a partnership formed in November 1982 between NT and GE in a joint cellular systems program to serve the emerging North American market for CMR. The site has 3 cells and serves about 100 cars equipped with in-car receivers. NT will supply base stations, cell-site controllers, and network switches, and GE, the cellular mobile telephones. The U.S. $2.5 million installation at Jacksonville is also a test trial and verification for the Toronto and Montreal Bell Canada cellular system. These two cities will have a total of 15 cells operating by late 1985, with switching based in Toronto for both.

1.4 Cost and Users

Most subscribers in the early phases of cellular implementation will be business people. Potential users will include those who travel extensively on their jobs and need to communicate during travel; those who must be reachable at all times, including when they are driving;

and those who have heavy demands on their time and need to use commuting time to communicate. Surveys have shown that the main reasons people will use CMR will be to schedule or reschedule appointments, obtain or receive directions, contact customers or suppliers, and make some personal calls.

From initial estimates the cost of such a service will be affordable by only large organizations or individuals who can justify the expense in terms of optimal time usage. Initial cost of a cellular phone will be about U.S.$2,000 with leasing costs about U.S. $70 per month. Charges will be about 40 cents a minute for local calls and long distance calls will involve considerable additional costs. Bell figures are $2500-$4000 for an operating unit and $100-$200/month in access charges and fees for calls. Currently, the CMR packages available in the Hertz and Budget luxury rental cars add approximately U.S.$10 per day to the rental. Local calls cost 50¢/minute. Long distance calls must be charged to a credit card.

Being expensive, this service will not be attractive to the average consumer in the initial phases. However, all major participants in the CMR market feel that the price will drop dramatically as demand develops and mass production facilitates cost reduction. This price reduction could attract many more CMR customers.

1.5 Future Trends

With the emergence of the CMR, there appears to be great interest in the product and hence a considerable potential for success. There is a definite appeal to users in being able to contact many places while being on the move. For example, the ability to contact a home office, a customer,

or a vendor while travelling along the highway may increase productivity for a business person. Also, CMR technology will ensure a higher quality of reception, thereby eliminating the current problems of fading and distortion that have plagued the mobile communications of the past.

There also seems a considerable interest in personal paging systems and one-way pagers, and their interconnection with CMR systems. As organizations strive to increase the accessibility of their staff, they are turning to CMR radio and paging systems to provide portable alternatives to the telephone. Sales of both are expected to generate sizable revenues for suppliers. However, while the CMR market will provide versatile service on a long term basis, a transitory one-way communication medium may be the portable pager. Therefore, in lieu of current CMR services, more and more customers needing mobile communications are installing paging systems. The pager technology has been available for more than a decade, but is now becoming popular and affordable to a wide range of both commercial and private users. Typical pagers selling for more than U.S.$500 a few years ago are selling today for less than U.S.$100. While early devices were able to signal users only with audio tones, newer models provide voice, numeric and alphanumeric communications. Indeed, as the price of hardware continues to drop, sales are expected to rise considerably and the market for paging systems should grow 18.8% annually over the next five years. Equipment and service sales were U.S.$975 million in 1983 and should exceed U.S.$3 billion by 1987.

Sales projections for CMR systems are quite optimistic and the CMR market has considerable growth potential. Novatel, the supplier of cellular equipment to Cantel, had approximate sales of $6 million in 1983 and expects 1984 and 1985 sales to be considerably higher. Cantel predicts it will attract 13,000 subscribers and $4.2 million revenues in its first year of operation. They feel that in 1988, revenues should be about $55.9 million and in 1993, they should have about 120,000 subscribers with revenues of $180 million. In the U.S., the total demand for cellular hardware is expected to be over $850 million in 1985 and almost $1.1 billion by 1986.

With growth predictions like these, it is no wonder that CMR is a virtual gold rush for investors in companies with cellular radio licenses as they expect to see their investments multiply ten-fold, and even hundred-fold, within five years.

One of the areas of possible expansion in the CMR market is the extension of cellular systems to include data transmission. One of the possible directions of this technology is the integration of portable computers into CMR. This marrying of two technologies would enable the business person who is constantly on the road to receive and send data in addition to voice. Thus the mobile business person would have access to various databases associated with his own organization and possibly those of vendors, customers, and the government.

Another development is the cellular portable telephone. In the U.S., General Electric has developed a battery powered, pocket-sized cellular portable telephone marketable by late 1984. Advantages to a device of this nature would be complete freedom to communicate while being anywhere (not just in one's car); also, paging and telephone functionality could be combined into one relatively small unit, thereby eliminating the need for two units. However, one problem with the hand-held models could be a lower quality of reception and transmission.

2.0 FIBRE OPTICS

2.1 Introduction

There is considerable interest at the present time in fibre optic transmission systems mainly due to the fact that these systems have virtually limitless capacity for information transmission. This new technology is quite different from the conventional methods of transmission since it employs light travelling through glass as opposed to electric current through conductors to move information such as phone calls, computer data and video signals.

Fibre optic developments have been taken very seriously by the telephone industry because of two critical improvements: more channel capacity and longer distances between the expensive equipment needed to retransmit signals. These retransmitters or "repeaters" are located at almost one and a half mile intervals along every conventional telephone line to amplify and retransmit the signal. They are a necessary part of the network because electrical signals deteriorate as they travel. However, repeaters are the least reliable link in the network and they sometimes introduce errors when handling computer data.

Using fibre optics will reduce both of these problem areas. With today's technology, a strand of optical fibre has 250 times the capacity of a copper wire and by next year, this capacity will be increased to 500 times, for the same inter-repeater distance. In fact, the limit on the capacity of the fibre is the speed of the laser used to generate the on-off pulses which represent the digitally encoded information. With commercial lasers available today, the fastest devices can pulse 400 million times per

second which is fast enough to transmit 6000 calls. The distance between repeaters on fibre optic cable has also been stretching out steadily. It is now commercially approaching 30 miles, and 100 mile spacing has been demonstrated in the laboratory at AT&T's Bell Labs. As a result, fibre optic networks located in metropolitan areas no longer need repeaters between their switching centres which makes the system more efficient.

2.2 The Physics Behind Fibre Optics

Imagine dropping a ping-pong ball into a sloping plastic tube just a little larger than the ball, one could visualize the ball bouncing between inside edges of the tubing as it falls through. If several exactly similar balls were dropped in succession, they would all follow almost, but not exactly, the same path. Now imagine shrinking that tubing down to the size of a strand of hair and sending a beam of light instead of the balls. The beam would bounce through the thin strand as the ball bounced through the tube. This simple analogy demonstrates the principle of operation of fibre optics.

Fibre optics technology is based on the optical principle of total internal reflection which states that when a light ray passes from one medium to another with a lower index of refraction (an indirect measure of the density of a material), it will be reflected back into the original medium. However, in order to be so reflected, the ray must hit the boundary within a given range of angles. The largest angle at which total internal reflection can occur is known as the "critical angle" or the "maximum propagation angle".

Exhibit 2.1 shows three rays from a light source (usually a laser diode-LED) entering the fibre. Ray A enters the fibre parallel to it and travels straight down the fibre until the fibre bends. Aligning the light source to travel parallel to the fibre is very difficult since the fibre strand is too thin. When the fibre bends, the light will be reflected off the inner edge of the cladding and back into the core. Ray B enters the fibre at an angle smaller than the maximum propagation angle and travels through the fibre by reflective process. Ray C enters the fibre at too great a propagation angle to be trapped within the fibre. It will therefore, be absorbed by the cladding and not transmitted at all.

2.3 Types of Fibre

The optical fibres have three basic types: multimode, single mode and graded index. They differ in the physical size of their cores, the amount of information each can transmit, and the distance the light pulses can carry information before retransmission is required. Single mode and multimode refer to the design of the fibre core which allows for the support of a single or several electromagnetic energy patterns or modes respectively.

Exhibit 2.2 compares the three types of fibre. Because of the differences in mode-carrying ability and index, light travels through each kind differently. The width of the core of single mode fibre approximates the wavelength it is designed to carry so that light travels through the fibre without bouncing off, and the quality of the signal at the output end of the fibre is very high. Multimode fibre can accommodate several wavelengths and can capture light entering the fibre from a wider range of angles. The ray

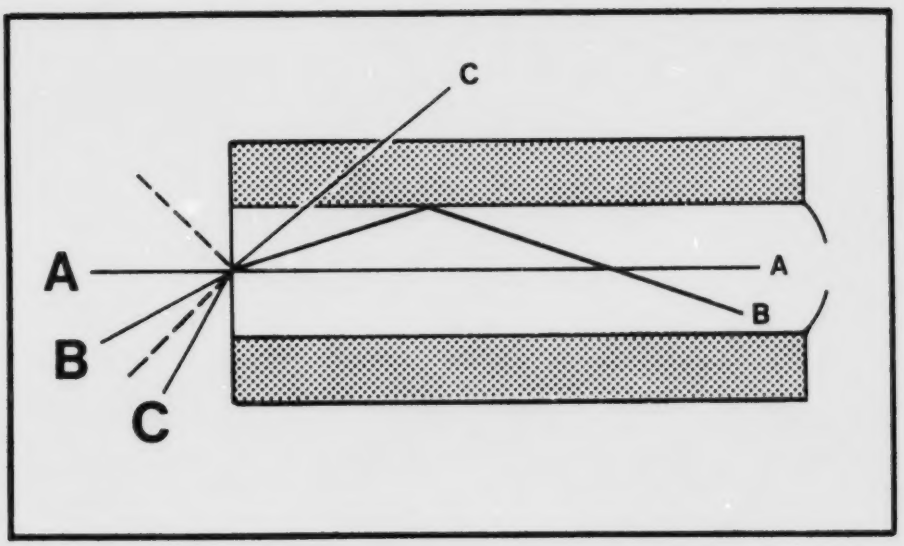


EXHIBIT 2.1

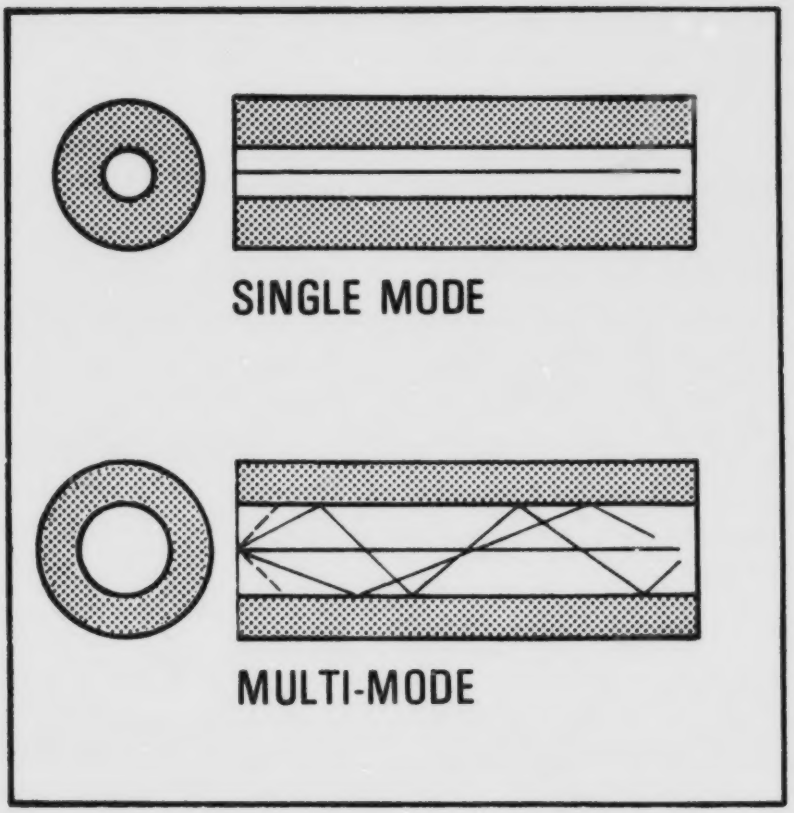


EXHIBIT 2.2

has less distance to travel along the axis than the ray entering the fibre at an angle. The wider the angle the greater the distance the signal must travel, thus a longer time is taken to reach the other end of the fibre, therefore, some parts of the signal will reach the output sooner than others. With graded index fibre the refractive index of the cladding fibre gradually becomes lower than the index of the core. This graduation means that the reflected rays travel faster than rays travelling along the axis, but since the reflected rays travel a longer distance all rays exit the fibre at nearly the same time. This is a condition strived for by fibre optic cable manufacturers since it means the distortion due to propagation delays within the medium would be minimized.

2.4 Advantages Of Fibre Optics

There are several advantages of using fibre optic cable over other transmission media such as coaxial cable or twisted-pair wire. The life span of fibre is about four times that of coaxial cable. In general, where coax will last twenty years, fibre optic cable will last about eighty. Exposure to moisture or humidity does not destroy the fibre's signal-carrying abilities. Fibre does not kink, as does twisted pair-wire, and it can be put into any configuration. It is also extremely light weight - a mile of optical fibre weighs only about seventy pounds - and is very strong. One company has developed a fibre for military use that can withstand the weight of a tank driven over it.

Since the information is carried in the form of light pulses, and the transmission medium, glass, is not an electrical conductor, the electromagnetic interference does

not affect fibre optic transmission. The fibre is immune to sunspots, static electricity, nuclear radiation and thermal noise. Signal leakage to other spectrum users is also not possible. This is the key reason behind cross-talk elimination in fibre optic networks.

All advantages of fibre optics are helping the development of its technology, however, perhaps the most important is its extremely large bandwidth. This large bandwidth (considered unlimited by some) allows phenomenal transmission speeds since there is a direct relationship between the bandwidth and the speed at which information can be transmitted through a medium.

It is interesting to note the race between fibre optic labs in Japan and the U.S. to build the fastest fibre optic system with largest inter repeater distance. Currently, Bell Labs newest laser has transmitted 1 billion bits per second through 75 miles of fibre without a repeater. However, this experiment was carried out under precisely controlled laboratory conditions, and not a typical environment encountered by commercial users. The experiment shows the current state and the future direction of fibre optic technology. David V. Lang, head of semiconductor research at Bell Labs, feels that with newer semiconductor lasers and fibre compositions, a transmission of 10 billion pulses per second can be achieved.

Other key advantages to optical fibres include much lower cost and smaller size (around 20 microns diameter). These advantages make it economically and technically a much more effective transmission medium.

2.5 Problems with Fibre Optic Systems

With the incredibly large bandwidth, the fibre optic cable would be ideally suited for high volume users. However, there are several problems - the major ones being splicing and connecting. Since the alignment of light sources is absolutely critical, high quality connection devices are most important. For example, if two pieces of fibre optic cable are spliced with a connector, an angular misalignment of 1 degree could decrease transmission efficiency by more than eighty per cent. Also, at each splice in the cable, there will be considerable losses (2-3 dB) due to signal attenuation. With such problems, it is apparent that the connector technology is a major area slowing the widespread implementation of fibre networks; however, with the cost of fibre dropping astronomically, there has been a considerable stimulus in the development of the connectors by such firms as AMP and Amphenol in the U.S., NEC in Japan, and more R&D is predicted for the future.

Another problem with fibre is the difficulty of repairing breaks in it. Generally, a broken line cannot be repaired to acceptable transmission levels, so it must be replaced. This can often cause problems if the cable happens to be located in hard-to-access areas.

The best uses for fibre optics are high volume data networks or new telco voice lines. Applications such as replacing an existing television transmission coaxial cable with optical fibre are just not practical at the present. Television transmission trunking would be very impractical with today's fibre technology. For example, a trunking system over wideband coaxial cable can handle 52 video

channels but optical fibre would handle six to nine channels. This is due to the fact that a good laser may put out a milliwatt of power, and this milliwatt divided through 52 channels on the fibre, provides 1/52 milliwatt per channel which is not nearly enough to achieve a good signal-to-noise ratio for cable TV transmission. Technology does exist that makes it possible to have fibre trunks, but it is complicated, expensive, and therefore impractical for cable TV use at the present.

2.6 Optical Fibre Implementation

In 1983, Bell Canada announced its commitment to exclusive use of fibre optic systems for all new inter-office trunking. In addition, replacements of copper-based inter-office trunks will be optical fibre. This will double today's optical fibre network (40 systems employing 16,000 fibre kilometres) by 1986.

Fibre optic cables are also used between switching centres. Bell plans to use fibre systems in short and medium long distance trunks to a maximum of 450 km, and as technology improves, economic benefits in the coming years could facilitate its introduction in the long haul network.

In Canada, at the current time, fibre optic networks are established and are proliferating. Alberta has already installed a fibre optic network and Saskatchewan is currently installing an extensive one.

Canada is definitely in the forefront of developing fibre optic networks. Since the mid 70's, Bell Canada has spent approximately $25 million in research and development of fibre optics. Northern Telecom has spent approximately $45

million. In 1984, Bell plans to spend an additional $25-$30 million on fibre optic development. With investment so high, it is apparent that fibre optics will continue to be a dynamic technology with great possibility for growth in future.

2.7 Future Developments

Developments in fibre optic technology have been occurring at an astonishing rate. For example, system capacity has been growing steadily and has tripled since 1983. This increase, coupled with the steadily decreasing costs of fibre, has led to the speculation that fibre networks may be used so economically for long haul that they may replace satellite and microwave links except for very remote or difficult to access locations. Undersea developments include U.S. plans to lay the TAT-8, a fibre optic transatlantic telephone cable to be operational by 1988.

With speed being an attraction of fibre optic technology, designers have begun to concentrate on developments to make it still faster. This has led to tremendous advances in lasers, particularly with semiconductor lasers. Originally, lasers were bulky gas filled tubes and were not very reliable in operation for long periods. However, semiconductor lasers, in their most advanced state, are small enough to fit through the eye of a needle. They can also switch on and off in an incredible billionth of a second.

Even though the semiconductor lasers caused fibre optic technology to advance by leaps and bounds, development has not stopped. At this time, the next threshold technology

is the optical processor. This processor has already been developed experimentally and has found certain specific applications, particularly in a military environment. This development came about because in current fibre optic networks, all processing is carried out electronically while transmission is optical. The electronic processing represents the slowest segment in the entire network since electrons through a conductor, under normal conditions, travel much slower than the light through glass. Therefore, if a system could be developed to utilize light pulses for processing as well as transmission, the overall rate of handling information would be much higher.

Interest in optical processors is not just limited to fibre optic applications since these processors can perform complex mathematical transformations, such as Fourier transforms, on large masses of data in parallel. Yet for simple operations such as addition and subtraction, the optical processor comes no where near the power or accuracy of the digital computer. Thus optical processors may not replace digital computers and microelectronics, but can complement them so as to tremendously increase the computing power provided by them. Optical processors are finding uses in military applications such as sonar, radar, and artificial vision.

There are numerous other developments in fibre optics. Ibraki Telecommunication of Japan has developed an ultra low-loss flouride optical fibre that will be able to send an optical signal around the globe without using a repeater. Although the performance of the new product is somewhat inferior to that of quartz glass optical fibre at the present time, theoretically, the losses in the flouride fibre could be reduced to one thousandth that of existing

optical fibres. The Ibraki laboratory plans to investigate a refining technology which will eliminate the impurities that cause the losses and will refine the production techniques.

3.0 SATELLITES

3.1 Background

In the 1980's many noteworthy developments are being made in the field of satellite communications as new applications and advancements are brought forth.

As communications networks expand and change in response to new demands and new technology, satellites will remain an integral part of the overall communications system even though their importance may be supplanted by the implementation of new technologies such as fibre optics.

Satellites, however, will maintain their prominence in many other applications that exist today and new ones will undoubtedly be developed so as to make the sphere of satellite technology a continually important area of study. Since feasibility and cost-effectiveness are key criteria, the degree of satellite implementation will depend upon how well these factors can be upheld and satisfied.

3.2 Satellite Television

One of the important uses of satellites today is in satellite television. This market is growing quickly and is attracting considerable investment as further growth is anticipated. The industry began in 1962 with the launching of Telstar 1, the first communications satellite. This satellite, owned by AT & T, could carry one television signal or twelve telephone calls at a time.

Today, video satellites can each carry up to two dozen television channels. These satellites hover 22,300 miles over the equator in a geosynchronous or geostationary orbit i.e. they orbit in space at the same speed the earth turns on its axis. This geostationary property is extremely useful since it eliminates the need for actuated tracking systems for satellite dishes. There is a whole group of satellites that is located above the equator between 72°W and 143°W (see Exhibit 3.1). This group is called the Clarke Belt in honor of science fiction writer Arthur C. Clarke who first proposed, in 1945, that satellites be maintained in space in a geostationary orbit. Many dishes are equipped with actuated drives which position them to receive signals from different satellites; however these drives are not nearly as complicated as the tracking systems required to follow non-geosynchronous satellite orbits.

Television satellites vary in design, but all have the same basic components. Westar 4, for example, is 7.1 feet wide, 21.6 feet long, and weighed 1,280 pounds at the start of its orbital life (300 pounds of propellant will be consumed during Westar 4's four to ten year life span). It contains control and propulsion systems that can be manipulated from earth should it stray from its orbit and it is equipped with solar panels that produce 935 watts of electrical power to operate all its systems.

What makes Westar 4 important to television viewers are its 24 transponders or relay systems which are similar to the channels of a television set. Each transponder carries up to 2,400 one-way voice circuits or one colour television program. Broadcast companies such as Home Box Office (HBO) or the major television networks lease a transponder from the satellite owner (RCA, Western Union and Telesat own the

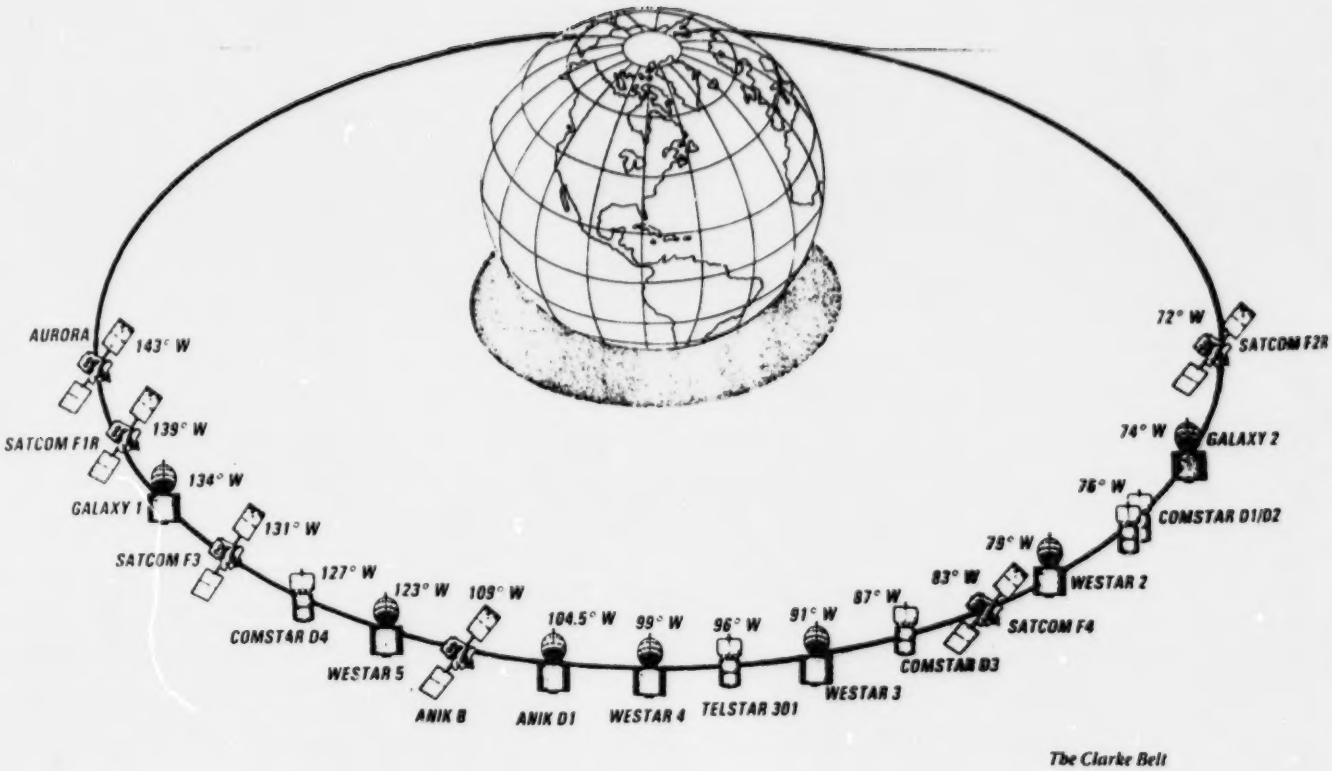

AURORA
143° W
SATCOM F1R
139° W
134° W
GALAXY 1
131° W
SATCOM F3
127° W
123° W
109° W
COMSTAR D4
WESTAR 5
ANIK B
104.5° W
99° W
ANIK D1
WESTAR 4
96° W
TELSTAR 301
91° W
WESTAR 3
87° W
COMSTAR D3
83° W
SATCOM F4
79° W
WESTAR 2
76° W
COMSTAR D1/D2
74° W
GALAXY 2
72° W
SATCOM F2R
The Clarke Belt

EXHIBIT 3.1

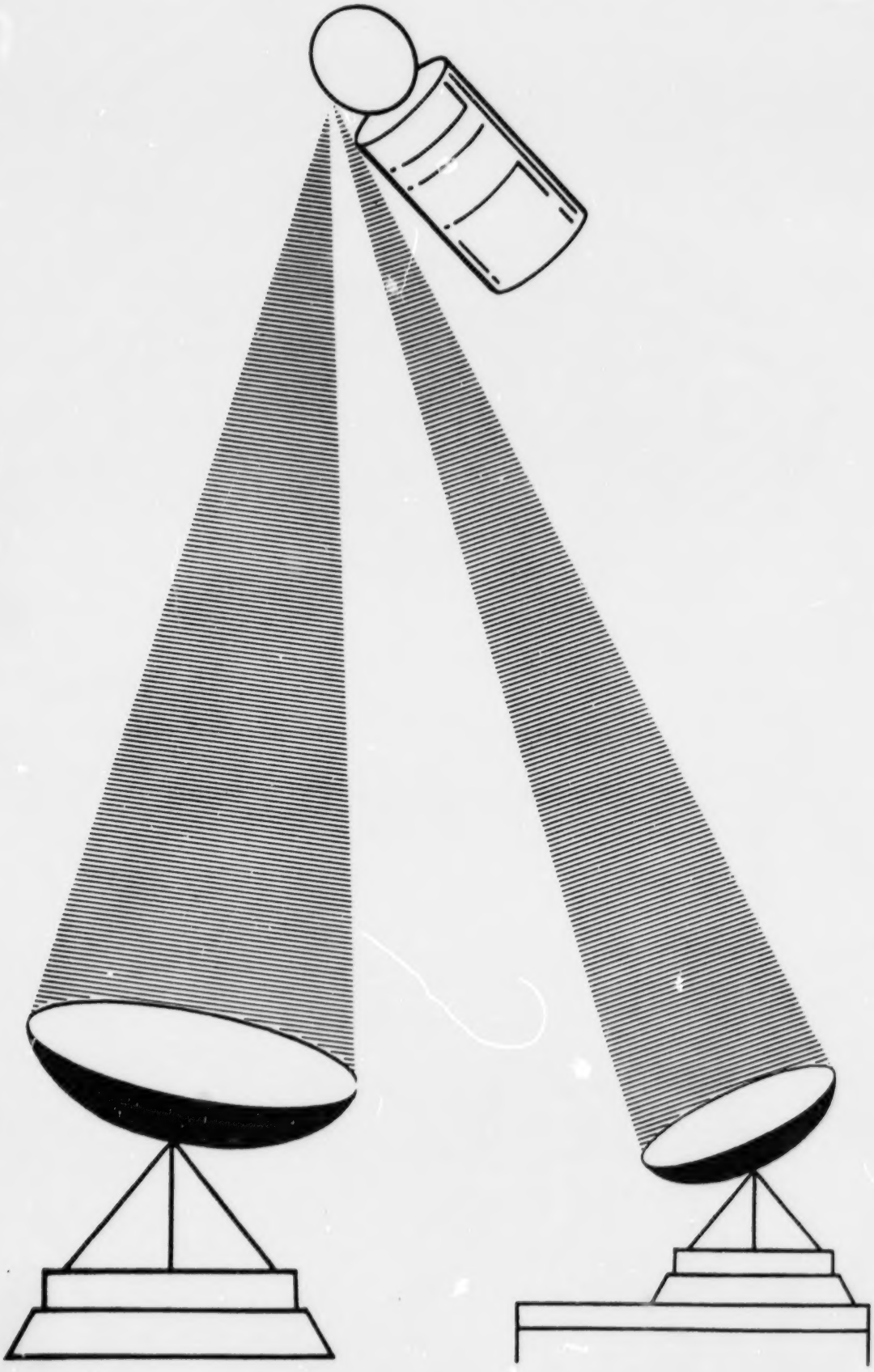


EXHIBIT 3.2

Satcom, Westar and Anik series respectively) to service each affiliate station or subscribing cable system simultaneously by blanketing the nation with a signal. Without satellites, television broadcasters would have to be connected with each rebroadcast station on separate earthbound microwave systems at a staggering expense.

However, if a consumer owns a satellite dish then the entire network of TV and cable middlemen can be bypassed and the consumer is free to choose from all the satellite programming available - more than 100 services - as compared to an average of 20 services available on cable. Scrambling technology may help to alleviate this so-called "piracy" by dish owners.

3.3 Satellite Television - Transmission

Television transmission begins at the TV studio where the signal is generated, processed, and fed to an "uplink" dish that beams the signal to the orbiting satellite. The satellite, in turn, beams it back to earth, where a "downlink" dish receives it. Generally, satellite transmissions are referred to as 6/4 GHz or 14/12 GHz - the first number referring to the uplink and the second to the downlink carrier frequency (GHz stands for gigahertz or a billion cycles per second) - (See Exhibit 3.2). The downlink signal is very weak, about as strong as one projected by a CB radio. Also the strength of the signal is not equal in all parts of the continent. The area covered by the satellite signal is referred to as the satellites "footprint" and signal strength is not uniform throughout this footprint. Therefore, in order to receive the signal, one must place a satellite dish geographically within the area covered by the footprint. Many returning signals are aimed around the Midwestern United States.

This includes some of the Canadian Anik satellites as well, since American use of the Anik satellites is allowed under a long-standing arrangement between Canada and the U.S. - one country with extra satellite capacity may serve the other when it has a shortage.

On paper, footprint charts resemble a series of crudely concentric circles, somewhat like the pattern created by dropping a large stone into still water. At the centre of the innermost circle the signal is strongest and gets proportionally weaker at points farther from the Centre.

3.4 Reception Equipment

Large and complicated equipment is not required to receive a satellite signal in one's home. Aside from the six to twenty foot diameter dish (smaller dishes are needed for DBS systems considered later) one needs a low-noise amplifier, generally referred to as an LNA, and a feedhorn assembly, a downconverter and a satellite receiver. (see Exhibit 3.3)

The concave satellite dish is made of highly reflective materials (usually metal) to gather and focus the signal to the feedhorn at the centre or focal point of the dish. Since the signal being received is weak, it must be amplified by the low noise amplifier. The signal is then channeled to the downconverter where its frequency is lowered from 4 GHz or 12 GHz (the downlink carrier frequency) and passed on to the receiver. A satellite receiver resembles a television receiver and performs many of the same functions. It provides the user with the controls needed to operate the equipment as well as further

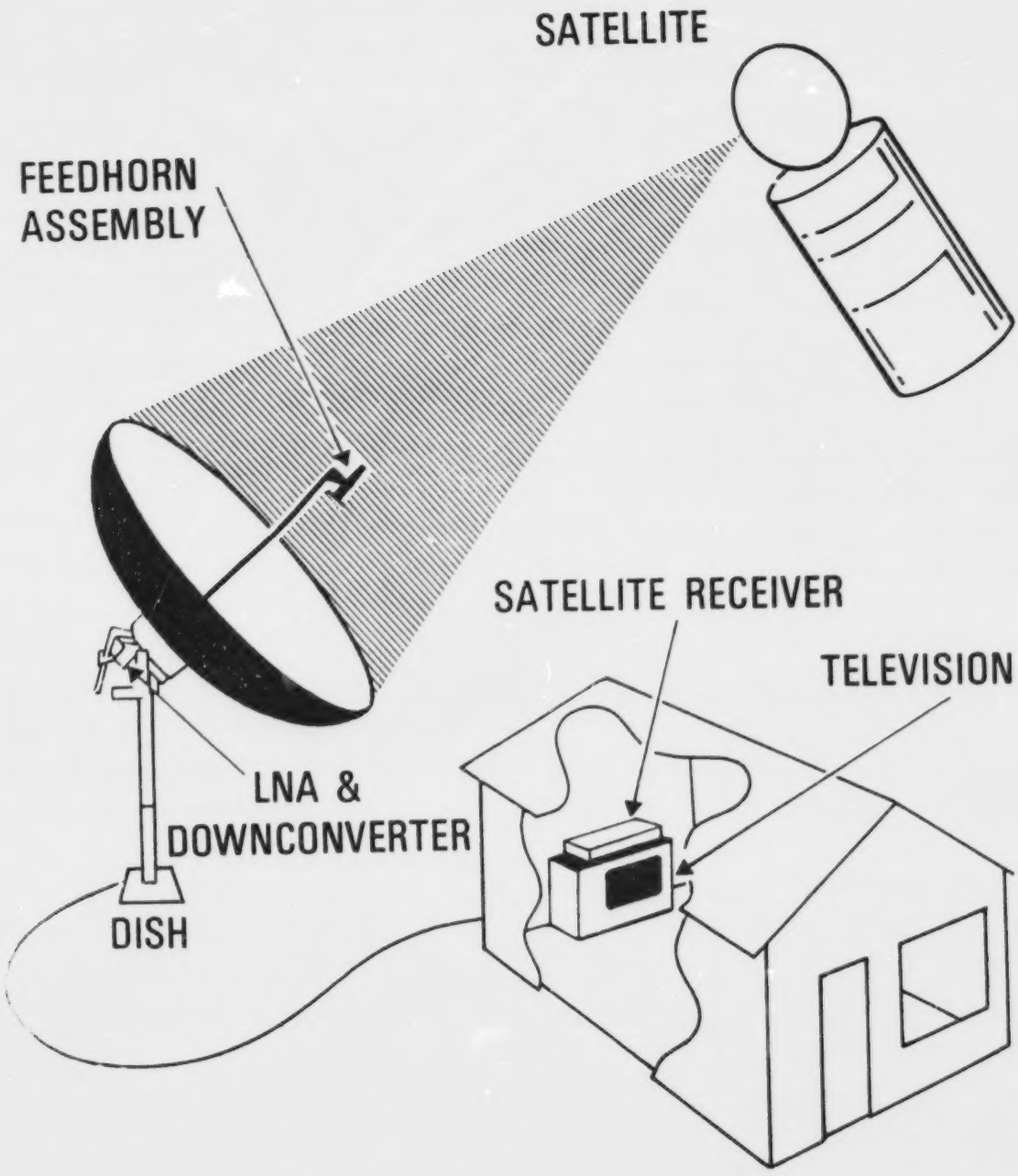

SATELLITE
FEEDHORN
ASSEMBLY
SATELLITE RECEIVER
TELEVISION
LNA &
DOWNCONVERTER
DISH

EXHIBIT 3.3

altering the signal so as to make it acceptable to a standard television set.

In order to pluck a program from the sky, the user begins at the receiver, which is in fact the control centre. It is difficult to discuss all receivers because there are many models with many different functions, but there are basic functions performed by all. The television satellites usually orbit four degrees apart (soon to be two degrees as the number of satellites in the Clarke Belt are increasing) and their positions relative to the earth are indicated by degrees as well: For example, Anik B is located at 109 degrees West. If the satellite dish is equipped with an actuator, which is a motorized drive, it will automatically move across the Clarke Belt and a signal strength gauge on the receiver will indicate when the user is getting close to the desired satellite. After locating and locking in on a particular satellite, a transponder on the satellite must be chosen to watch a particular program. This is analogous to changing channels on a television set.

However, with satellite transmission, there is a difference between 'vertical' and 'horizontal' transmissions which makes it complicated since this transmission technique allows the number of programs carried by a satellite to be doubled. This is done by projecting two signals on overlapping frequencies without interfering with one another. The signals can be distinguished separately if one is broadcast on a vertical plane and the other on a horizontal plane. This method is referred to as polarization which enabled recent satellites to carry twenty-four transponders instead of twelve on older ones. The user obtains horizontal or vertical transmissions by

pressing the appropriate buttons on the receiver. To the user, the plane of transmission is simply a convenient way to access more signals, and hence, a greater number of programs.

Therefore, in order to watch satellite TV, the user generally buys a satellite dish (equipped with LNA, downconverter etc.) and a satellite receiver. Depending upon the geographical location of the user, and the features of the equipment, a complete system costs approximately U.S. $2,000 to $5,000.

Currently in the U.S. and Canada, ten foot dishes are quite popular - approximately 200,000 in the U.S. and 30,000 in Canada. These dishes can access approximately 100 channels depending upon their exact geographical location. Increasingly, 1.8 meter dishes are coming into use.

3.5 Direct Broadcast Satellites (DBS)

The satellite dishes considered thus far, those of approximately 3 meter (10 foot) diameter, were not initially meant for the home market. Initially, satellite dishes served as the receiving station for cable companies or other distributors. Then, the signal from the dish was relayed to the home via cable.

However, certain people decided to receive the TV signals directly from the satellite thereby eliminating the cable company as the middle man. Interest in the satellite market flourished for reasons besides cost. Greater choice of programming influenced many people into purchasing

satellite dishes. Generally, if one can receive signals from all the satellites in the Clarke Belt, up to one hundred channels can be received. This provides a tremendous variety in programming since some of the channels cater to very specialized audiences eg. those interested in music, sports etc.

The home market also spawned interest in a satellite system specifically aimed at the consumer and not the cable companies. This would be known as a Direct Broadcast Satellite (DBS) system and would be designed and operated specifically for home users. A "true" DBS system would employ a small dish that would be more suitable to a residential environment. Since dishes would be small (approximately the size of an open umbrella), they would be cheaper (less than U.S. $500) and would also blend into the residential environment somewhat more unobtrusively.

If smaller dishes are to be used, different uplink and downlink frequencies would have to be incorporated into the system because the higher the carrier frequencies, the smaller the dish required to capture the signal with high quality reception.

Since the smaller dish would be a key point in DBS, designers decided not to use existing TV satellites which used mostly 6/4 GHz - only a few of the most recent ones operate on 14/12 GHz. They felt that in order to have dishes of less than 1 metre diameter, new satellites would have to be designed and built that operate on 17/12 GHz. A DBS based satellite network would cost more than $500 million and require several years to be developed, tested, and made operational. These satellites would be designed to carry both television and radio programs; however, they would cost about U.S. $30 million each which is twice as

much as traditional 6/4 satellites cost. They would also require higher transmission power than 6/4 or 14/12 satellites in order to effectively reach the small dishes.

It is widely felt that DBS would lack the amount of new programming needed to persuade North American viewers that they should spend U.S. $40 a month, the service would likely cost. A proposal was brought foward in 1980 in the U.S. by Communications Satellite Corp. of Washington, D.C., (COMSAT) to provide a six channel pay-TV system delivered by high powered 17/12 GHz satellites to residential users with 0.8-1 metre dishes. This system would be aimed at the 20 million U.S. households that would still be without cable by 1986, the originally scheduled start up time for this service.

Aside from the DBS developments in the U.S. market, there has also been interest on the Canadian scene. The Federal Government is interested in developing a DBS system to serve the 1.5 million people who live in regions of Canada served by less than two television channels. The geographic location and small population of some regions make them highly unattractive to cable companies because of the high costs of running cable to them.

The Federal Government is interested in upgrading the television service in underserved areas of Canada such as the Far North and the northern regions of several of the Western provinces. The Department of Communications is considering implementing a DBS system that would serve these regions better. The system would allow for several more Canadian channels and at least one of the major U.S. networks to be carried thereby giving viewers greater choice in programming.

One cannot underestimate the importance of this proposed expansion to the residents of these regions. Being away from the major centres often makes leisure and recreation more important to them.

In order to facilitate this expansion of service, the federal government seems to favour a DBS type of system, but not a true DBS system. The system they are considering is "Direct-to-Home Satellite" broadcasting or "Interim DBS" and it would employ the existing Anik C3 and C2 satellites. These satellites operate on a 14/12 GHz system which makes them fundamentally different from the proposed DBS satellites which operate on a 17/12 GHZ system. Since the uplink frequency is lower with the 14/12 satellites, the satellite dishes used would be somewhat larger (1.2 - 1.8 metres) than the 0.8 - 1.0 metres diameter of the 17/12 system.

Therefore the "interim DBS" system would meet the needs of DBS, without incurring exorbitant startup costs ($400 - $700 million) of building, testing, and launching new 17/12 satellites. This is hoped to make the system somewhat more attractive to potential users and investors.

In the U.S., "true" DBS is having problems finding financial backers. For example, COMSAT estimates its system will cost more than $600 million and it has been looking for a partner to share the burden of the expensive venture from the beginning. COMSAT almost reached an agreement with CBS Inc. of New York, but the network pulled out when it decided the risks were too high to justify the inital investment of $70 - $80 million. Apparently, CBS followed the lead of Interamerican Satellite Television Inc., backed by Australian publisher Rupert Murdoch, which

dropped its plans for a DBS system late in 1983. The only notable commercial entry into the interim market, United Satellite Communications Inc. (USCI), a joint venture of General Instrument Corp. and Prudential Insurance Co., started limited operations in November 1983 but failed to attract the $40 million in new financing needed to expand its service to a more profitable level.

Despite the cost effectiveness of the interim DBS, there are other problems that must be considered. One of the important criteria is that all of the programming that now runs on the 6/4 satellites (HBO, Showtime, etc.) would not be available on the 14/12 satellites unless some sort of agreement is made with the broadcast groups to allow the programs to be on both 6/4 and 14/12 systems. As it stands now, if one has a receiving dish for 14/12, one would not receive programs from any of the 6/4 satellites. This would definitely pose a problem for a firm trying to attract customers to maintain profitability in the highly competitive viewer market.

A second problem with interim DBS is the potential for weather interference because of the downlink frequency of 12 GHz at which the signal wavelength gets closer to the raindrop size. This causes interference at the dish because the downlink signal is distorted by rain and bad weather. This problem is not encountered by 6/4 GHz systems.

3.6 The Mobile Satellite (MSAT) Program

The Federal Government is also interested in developing a mobile satellite (MSAT) service that would provide reliable mobile communications services across Canada. The system

would provide wider coverage thereby rendering it unique from other mobile communications systems employing terrestrial transmission.

A demonstration system is to be developed and implemented by 1988 which will comprise a satellite in geostationary orbit, a number of earth stations for satellite control and mobile communications control, and a large complement of mobile earth stations for land vehicles, ships, aircraft and field operations.

The long-term MSAT plan involves the implementation of a commercial MSAT system in the early 1990's by the telecommunications industry. This system would provide mobile communications over a large area and it would have widespread applications, ranging from emergency medical uses to disaster relief and from law enforcement to trucking.

The MSAT satellite would operate with an uplink in 821 - 825 MHz band and a downlink of 866 - 870 MHz in the UHF spectrum. It would also operate in a higher frequency band, approximately 12 GHz, for satellite backhaul facilities.

It is expected that the large volume of equipment generated by terrestrial cellular mobile radio systems could be ecomomically adapted for use in conjunction with MSAT. Based on the tremendously large satellite antennas proposed, contact between mobiles, base stations, and possibly portable digital message terminals would be easily achieved. It might also allow true nationwide radio paging.

MSAT is aimed mainly at serving rural or sparsely populated areas.

Exhibit 3.4 illustrates the proposed MSAT concept showing the various services that will be provided.

3.7 Future Developments

At the present time, full potential of communications satellites is not realized due to the development of other competing technologies such as fibre optics. Generally, satellites have been the most efficient method of communicating over distances greater than a thousand miles. However, due to the low cost and tremendous capacity of fibre optic cable, it may become more economical to use it instead of satellites to perform this function. In the past, a major problem with fibre optic cable has been obtaining the land rights in order to lay the cable; however, this seems to have been overcome by making arrangements with railways and other rights of way owners. This would tremendously reduce the cost of implementing a long distance network, and in fact, it would be much less than the cost of building, testing, launching, and maintaining a satellite orbiting above the earth.

However, in spite of the attractiveness of fibre optic cable, satellites will not be replaced entirely by optical cable because there are certain communications applications where satellites are, and will continue to be, the preferred way. For example, there are certain areas of

M-SAT SYSTEM CONCEPT

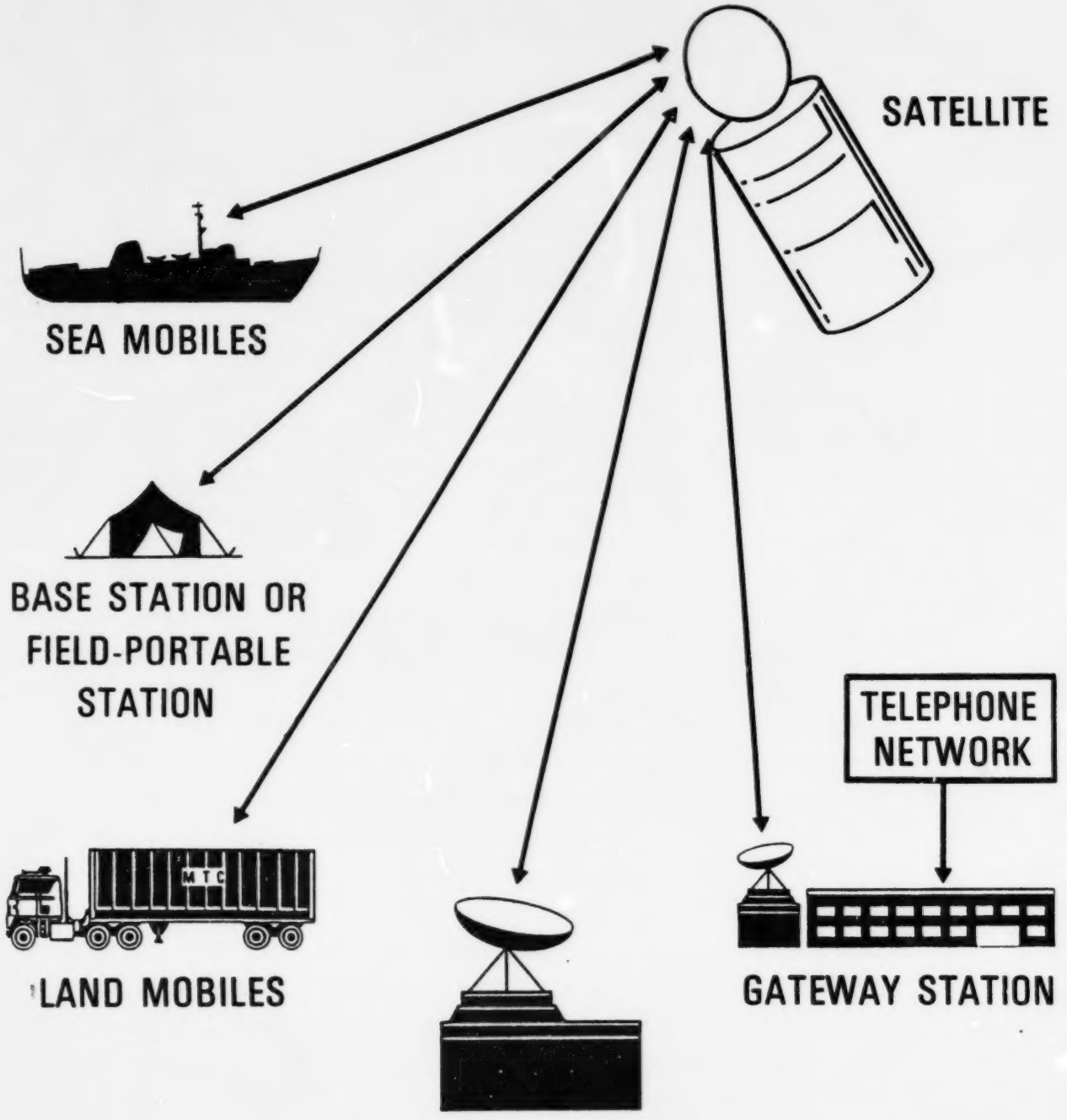


EXHIBIT 3.4

Canada where it would be impractical to lay optical cable due to the harshness of the terrain, for example in rugged Rocky Mountain ranges of the West or the barren tundra and permafrost of the Far North. In such cases, it would be easier and more economical to bounce a signal off a satellite to a receiving dish thereby completely circumventing the problems of going over land.

One new innovation in satellite technology is the concept of "tethered satellites". Such a satellite is to be connected to a space station, a space shuttle or perhaps even another large satellite by means of some sort of a conductive cable. The aim is to see whether payloads on long conductive cords might generate enough electricity to meet the power needs of future space stations. This idea would work on the principle that electrical current is generated as metallic cables are moved in the earth's magnetic field. The cord would probably be a 1/16 inch braided Kevlar composite with a 0.02 inch conductive wire running through it.

Another use of this system would be to boost a space vehicle into an outer orbit. For example, an orbiting Space Shuttle's empty fuel tank could be tied to a long cable and released downward. Cutting the cable, when it reached an appropriate length would kick the shuttle into a higher orbit without requiring any additional fuel.

Finally, an orbiting space vehicle leashed to a satellite would be subject to a net force that could serve as an "artifical gravity" to make the astronaut's movements easier. This gravity would only be a fraction of the gravity at the earth's surface but it could be sufficient to give future astronauts welcome relief from constant weightlessness.

The gravity could also make it easier to berth smaller spacecraft in a space shuttle, and servicing the shuttle would be easier since tools and equipment would no longer float away.

While these applications are theoretically very promising, questions about their feasability remain. However, a test model of a tethered system is to be launched around December 1987 and it is expected that this will resolve many of the unanswered questions.

In DBS, predictions are that it will continue to have financial problems and thus its progress will be limited. However, it may possibly find new hope if cable companies decide to support DBS as simply another source of income.

The MSAT program is also a very costly venture whose long term future is uncertain. Feasibility and the investment decision would depend upon the results of the 1988 test system. Since this system is aimed at 1990's, the sophistication of complementary technologies and support systems may also play a vital role in MSAT's success.

Finally, it seems as though satellite dishes will continue to proliferate in the residential environment and as their popularity increases, costs will drop thereby making them even more attractive to the consumer who is looking for television programming variety.

4.0 LOCAL AREA NETWORKS

4.1 Introduction

The concept of the local area network has generated a tremendous amount of interest over the past few years and much of this is due to the continuing developments in the areas of office automation and integrated office systems. Integration is the one factor which must tie all viable office automation approaches together. An integrated system must be integrated from a functional, application, and equipment standpoint. The investment needed to create such an automated office environment is significant, and multi-functional approaches must be employed to make office systems as productive and cost effective as possible. Integrated systems provide savings in terms of the incremental addition of functions, but also increase productivity due to their inherent resource sharing capabilities. Separate systems inhibit the intra and inter-company flow of information. With integrated systems, information need only be entered once. Information residing on the system can be used by all persons (permitted access) and transmitted within and outside the company or as desired security systems permit. The major integration philosophies that exist today include coaxial-based local area networks (LAN's) and voice/data PABX (private automated branch exchange) systems.

4.2 Evolution

The concept of the Local Area Network evolved from a need to allow distributed processors and terminals to communicate with each other more effectively and at lower costs.

Presently, there are no precise standards or definitions governing LAN's; however, one working definition of LAN is: "An inexpensive digital system connecting dissimilar computers and other peripherals in a small geographic area, either various desks in an office, floors in a building, or buildings on a campus". Thus, a LAN can be considered a high speed communications network to connect different business-type machines in one continuous (local) area. It allows for universal access to required data at high speed and at a reasonably affordable price. This multi-user access capability contributes to increased efficiency and consequently, higher production through the use of shared facilities. Cost effectiveness may also be achieved since the LAN is usually owned outright by the user, thereby eliminating monthly carrier costs or user fees.

Over the past few years, LAN's have evolved significantly. First generation LAN's offered the user point-to-point data transfer capabilities between stand alone processors. However, little intelligence was involved in the actual network control environment since these networks allowed little more than high speed data exchange between computing devices.

Second generation LAN's allowed for more power and versatility since they enabled the user to connect processors to a coaxial channel thereby allowing these processors to communicate with each other and have access to different disk files and printers. At this state of LAN development, a processor, previously limited to using its own local resources, could now access these resources as well as printers, disk drives, etc. that are associated with other processors connected via the coaxial channel.

An example of a second generation LAN was Data points Attached Resource Computer (ARC) system network that was introduced in 1977.

Third generation LAN's combine not only processors and distributed resources, but they also serve to link LAN's to other LAN's, stand alone systems or still other systems or resources via telecommunications channels.

Flexibility of the third generation LAN extends resource sharing to its maximum. All physically connected items are considered resources - disks, printers, tapes, terminals and telecommunications channels - thus breaking down geographical barriers and allowing for true integration of devices. It is important to note that with third generation LAN's, all file formats are common, both in accessibility and storage style and no matter what the language or manner in which they arrive at a particular point in the system.

4.3 Baseband and Broadband LAN's

The simplest type of network is little more than several wires connecting two or more (usually personal) computers together. File transfer is possible between these computers, however, this requires running a special program at both computers. This approach is desirable only for very small installations and is not really a local area network, due to limited sharing of resources.

There are two basic types of LAN's being implemented today: baseband networks and broadband networks.

In the baseband network, digital pulses are put directly on the cable (without a carrier frequency), whereas in the broadband technique, a high frequency carrier is modulated to carry the required information. There are also bandwidth differences between the two methods. Bandwidth is the range of frequencies that can be transmitted efficiently by the system. Indirectly, it is also a measure of the transmission speed which can be supported by that system; high speed transmission requires a large bandwidth system.

Baseband networks use the entire bandwidth (usually coaxial cable or twisted - pair wire) for a single information channel. Time division multiplexing (TDM) is usually used to permit many users to transmit on the same channel. Data and voice transmissions can generally be handled, but not video. There is considerable difficulty in obtaining voice and image integration using a baseband system. Broadband networks, on the other hand, divide the cable bandwidth into multiple information channels with each channel used for separate transmissions. Data, voice and video can be transmitted simultaneously on the cable, just as a number of television channels can be transmitted on a cable TV system. With broadband, frequency division multiplexing (FDM) is usually used instead of the TDM methods used in baseband techniques.

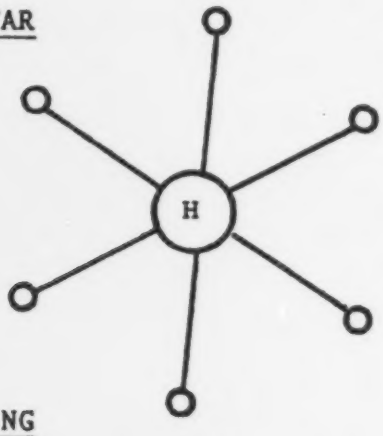
4.4 Topologies

There are three basic system configurations which are usually used in the design of local area networks: a star, ring, or a bus (see Exhibit 4.1). Star configuration uses a central switch (as in a PABX) and user devices access the switch using many-to-one-point links, usually of twisted wire pair.

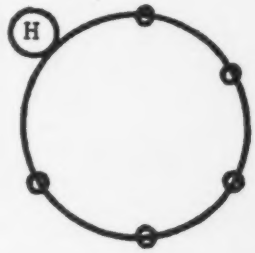
L.A.N. ARCHITECTURE

LOCAL AREA NETWORKS COME IN A VARIETY OF SHAPES AND SIZES. IT IS THE TOPOLOGY OR SHAPE OF THE NETWORK THAT IS THE INITIAL CONCERN.

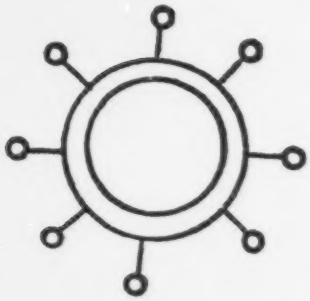
1. STAR



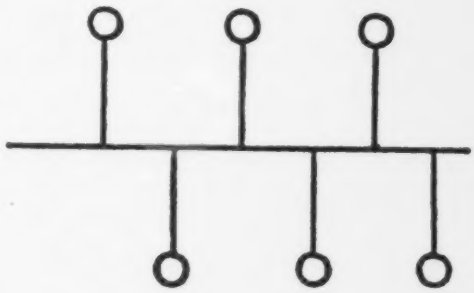
2. LOOP



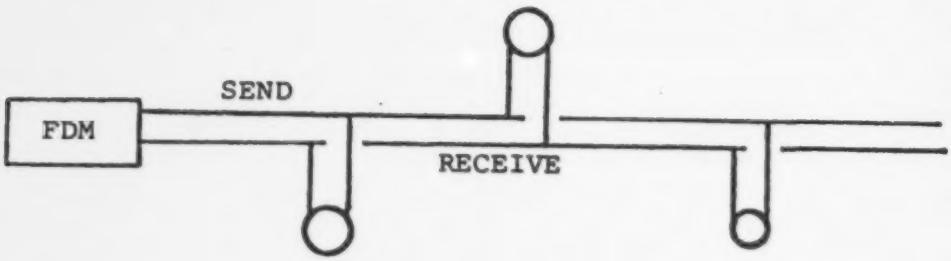
3. RING



4. BASEBAND BUS



5. BROADBAND BUS



LEGEND H · HOST OR CONTROLLING COMPUTER

O INTELLIGENT TERMINAL OR MINICOMPUTER NODE

EXHIBIT 4.1

With a star configuration, there is very little operational difference between the LAN and an ordinary PBX system. Ring configuration, on the other hand, uses distributed control. User devices are connected to the network with limited distance between adjacent devices. High bandwidth cable (usually coax or fibre optic) links the various devices in a series of nodes which act as repeaters within the network and also control access to the network. Loop configuration is simply a variation of the ring configuration and will be discussed in detail in the following section. Bus configuration provides a distributed switch with device interfaces similar to a ring configuration, but, in a bus configuration, i.e. users tap into a single high-bandwidth communications channel (analogous to a communications highway) and the stations are not required to act as repeaters. There are baseband and broadband buses differentiated by size of useable bandwidth and the use of a carrier frequency upon which to modulate information.

4.5 LAN Access Control

(a) Bus Systems

The most common methods of controlling connections to the LAN are Carrier Sense Multiple Access/Collision Detection (CSMA/CD) and token passing. CSMA/CD requires each processor to "listen" to the wire (the bus to which everything is connected) to see if there is a current transmission. If the wire is free, (nobody else is transmitting) the message is sent. If two processors attempt to access the bus simultaneously, there is a "collision" and both stations stop transmitting and try again at a random later time.

The CSMA/CD system was developed by Xerox for Ethernet, and is suitable for data traffic that occurs in frequent bursts as opposed to continuous transmission for long periods of time.

(b) Ring Systems

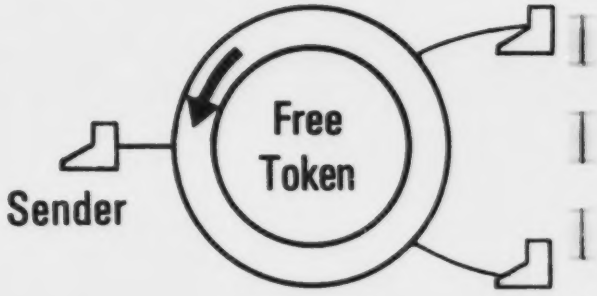
Token passing is usually used in ring networks. One or more empty packets circulate around the "ring" (see Exhibit 4.2). When a station (or device) has information to transmit, it finds the first empty packet (called a token), loads data into it and sends it on to the destination. The destination copies the data of the packet, marks it delivered and sends it back to the originating station. When the originating station retrieves the packet, it changes the packet's status to empty and returns it to the ring. At this point, it cannot again fill the packet thus ensuring that one station cannot monopolize the network. In token passing, there is no need for a central control station since control is distributed throughout the ring.

One variation of the ring structure that is quite popular and does not employ token passing is the loop structure. The loop is different in the fact that it uses a polled multi-drop method of communications control.

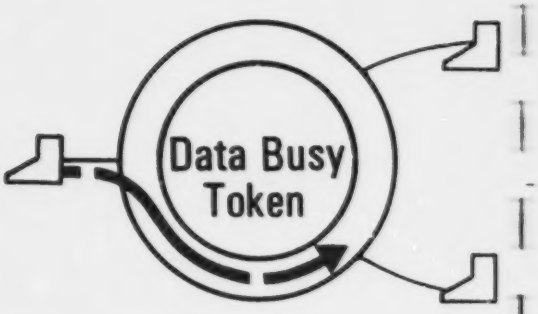
With the polled multi-drop method, each device is polled, or interrogated, in sequence by the central computer to see if it has data to transmit. If the device does have, it transmits the information onto the loop to be picked up by the central computer. If it doesn't, the next station on the loop is interrogated to see if it has anything to transmit, and so on.

TOKEN PASSING

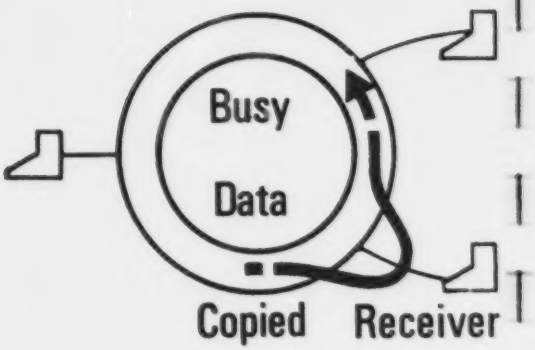
- SENDER WAITS FOR FREE TOKEN



- ADDS DATA AND ADDRESSES AND SETS TOKEN BUSY



- RECEIVER COPIES DATA AND SETS "COPIED-BIT"



- SENDER REMOVES ITS OWN DATA AND GENERATES NEW FREE TOKEN

EXHIBIT 4.2

Both the polling and token passing methods are based upon time division multiplexing since either method will allow a station to communicate with the rest of the network for only a finite period of time. Differences in the two methods are based upon differences in protocols as well as operational considerations such as: how does the system decide who has priority to send and receive, how long will they communicate before they must pass control to someone else who is waiting on the system, and how will the system know when the station with priority is finished sending or receiving.

4.6 Choosing a LAN or a PBX

One question often raised is that if a third generation LAN offers true sharing of resources, why should one consider a PABX based system?

The PABX enables telephones and computers to be tied together and serves both a voice and data communications needs of the organization. The digital PABX is basically a large digital switch. When a telephone is picked up, or a terminal turned on, the PABX connects it to whatever resource the user wishes. If a telephone call is made, the caller is connected to another PABX telephone or to an outside voice channel. A sophisticated PABX also provides connections (mostly twisted pair) to allow virtually any terminal (or processor) to be connected.

There are several advantages to using a PABX including simple connectivity, ease and economy of adding terminals once the premises is wired for the PABX. A PABX also solves the common data processing problem of "port contention" (having a greater number of users than the physical capacity of the processor). This can be done because the PABX allows for the addition of casual terminals over and above the computer port capacity.

One of the major considerations when examining LANs vs. PABXs is that typical PABX is designed to accomodate voice and low-bandwidth data traffic, while local area networks (mostly based on coaxial cable), are designed to accomodate the high-bandwidth traffic which is often in the form of frequent bursts of data.

However, advancements are being made in the area of high bandwidth PABX which expands the versatility of the PABX system.

Successful implementation of either the coaxial based LAN or the PABX involves a detailed analysis of a large number of practical considerations such as installation, voice/data integration, multi-vendor integration, terminal usage, distances between devices, transmission speeds and total cost. Thus, both types of systems can provide adequate service, however, one may be preferable to the other depending upon existing conditions or, perhaps, future development possibilities of the user's environment.

It is important to note that PABX systems provide an easier solution to incompatibility between terminals; however, some vendors' products still will not communicate with those of others, unless protocol conversion and emulation bridge the compatability gap. This criteria applies to LANs as well, since protocol compatability must also be considered as a factor in determining whether or not the different terminals connected in the LAN will be able to communicate with each other.

4.7 Future Trends

LAN technology itself does not really introduce any hardware that did not exist prior to the inception of LANs, but applications of the hardware and the methods of use are somewhat different. For example, coaxial cable has been used for many years in various applications. Various terminals (or devices) that LAN's usually integrate have also been in existence for sometime. However, they have not previously been interconnected in an integrated fashion. Thus, it is this advancement in connectibility and integration that is facilitating progress. The newest development in LAN technology is the development and implementation of the so called "fourth generation" local area network.

Fourth generation networking merges voice, data, and text and messages into a global network using both the twisted pair telephone wire of the sophisicated PABX and the coaxial-based information pathway. Thus it represents a major step forward in the ability to connect different devices in a hybrid cost-effective fashion.

With this approach, heavy users retain all the speeds of coaxial pathways, while lighter workloads are handled economically through the twisted-pair wire connection. Through either pathway, the simple user interface is unchanged, response time remains good, and resources are available to all users throughout the network.

Thus, we have the case where LAN concepts and PABX concepts are no longer seen as two different approaches to getting the same job done, but rather as an integrated approach to solving the voice and data communications problem. An example of this technological advancement is an application

to the present office environment. With PABX/LAN integration, incoming telephone calls which cannot be connected, for some reason, to their destination could be redirected to a storage device on the local area network where a message could be stored much like an answering machine. A note would be placed in that user's electronic in-tray to the effect that a telephone message is waiting (voice messages could be used as an alternative to text messages). The user could then dial the device, where the message is stored, to listen to the message.

Thus through careful integration of different voice and data systems, this and other new facilities will become available to the office user.

It is this integrated approach that allows for a more efficient system, thereby facilitating an advancement of the state of technology.

Considering the fact that when one tries to connect various devices together, in order to form some sort of network, compatibility is perhaps the most important criteria. Many companies are involved in the creation of various protocols and architectures so as to create the compatibility that is required for interconnection.

One of the major PABX developers in this area is Northern Telecom. Northern has developed the concept of an "Intelligent Universe" which is quite nicely described in a recent annual report; "Information in the form of words, images, voice or numbers enters the networks through integrated multifunction information systems. These systems are based on data terminals, computers, word processors, facsimile machines, electronic telephones and other yet-to-be invented electronic equipment. The

information then travels through the networks where intelligent switching and transmission systems electronically effect and control its flow among users".

Since 1978, Northern Telecom has advanced the development of the Intelligent Universe through the "OPEN World" concept. (Exhibit 4.3)

This "open" (Open Protocol Enhanced Networks) system will be able to accommodate most types or makes of equipment, and will allow all major office communications functions to be undertaken on one integrated system. The OPEN World comprises a planning framework to assist users to plan and build their own information management systems, and includes the provision of telecommunications products, services and features for the implementation of such systems.

These networking systems are generally centred around a digital PABX and use existing twisted-pair wiring as a medium of interconnection. This use of telephone wiring that is already in place eliminates the need for rewiring the site to be served by the network. In addition to providing switching systems and other necessary hardware to implement this integrated operation, Northern will also provide interface specifications to other manufacturers to enable them to design equipment that will work cost-effectively in an SL-PBX based system. At the present time, Northern has agreements with Digital Equipment Corporation, Sperry Univac, and Wang to ensure maximum compatibility of equipment between manufacturers.

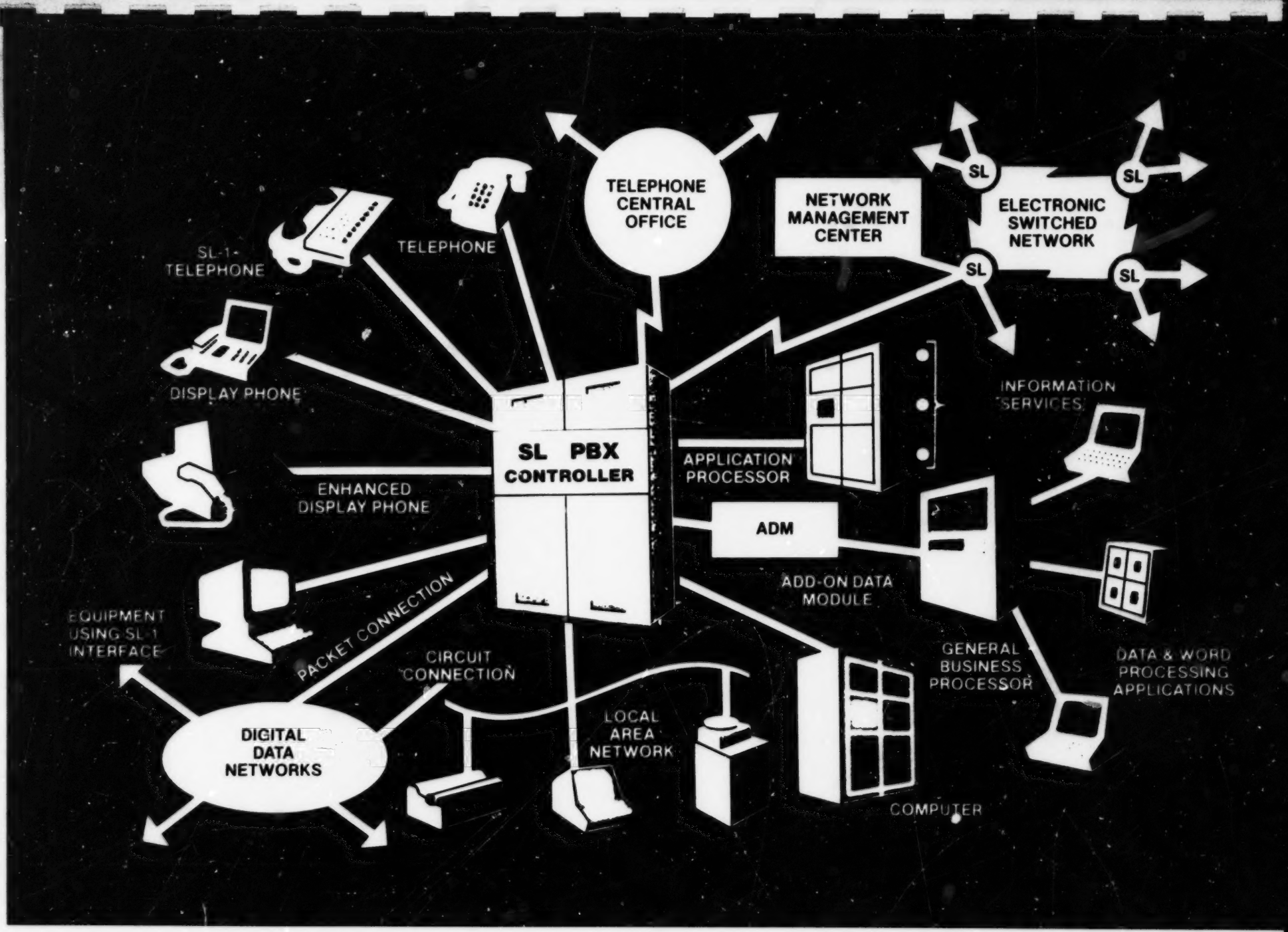

TELEPHONE CENTRAL OFFICE
NETWORK MANAGEMENT CENTER
ELECTRONIC SWITCHED NETWORK
SL
SL
SL
SL
SL-1 TELEPHONE
TELEPHONE
DISPLAY PHONE
ENHANCED DISPLAY PHONE
SL PBX CONTROLLER
APPLICATION PROCESSOR
INFORMATION SERVICES
ADM
ADD-ON DATA MODULE
EQUIPMENT USING SL-1 INTERFACE
PACKET CONNECTION
CIRCUIT CONNECTION
DIGITAL DATA NETWORKS
LOCAL AREA NETWORK
GENERAL BUSINESS PROCESSOR
DATA & WORD PROCESSING APPLICATIONS
COMPUTER

EXHIBIT 4.3

Northern also supports the International Standards Organization's OSI (Open Systems Interconnect) standard of compatibility for different devices. Northern's technological designs also allow for the provision of gateways to other suppliers LANs which may involve X.25 packet data communications interfaces or perhaps IBM's System Network Architecture (SNA) configurations.

4.8 Conclusions

In the area of Local Area Networks, there seems to be a definite trend towards the merging of PABX and LAN technologies thereby creating a much more powerful network. Presently, an example of this merging is Datapoint's ARCnet and its Information Switching Exchange. Other manufacturers are also working on the development of these so-called Fourth Generation LANs which allow much more integrated networking.

Presently, certain applications of LANs are limited by the rate at which data can be transmitted through a particular medium. For example, using existing twisted pair wiring, one is limited by a small bandwidth which would consequently limit the usefulness of the lines under certain applications. However, advances are also being made in this area; Northern Telecom is working on a method which will allow data transmission of 1 million bits per second through existing twisted pair wiring using a combination of out of band modulation techniques, digital compression techniques, and regenerative process through the use of repeaters. Using other transmission media such as coaxial cable or fibre optic cable may allow for much

greater bandwidth. Perhaps, in the future, all networks will be constructed using fibre optic cable because it has a very large bandwidth, is cheap, and has favourable transmission properties.

Through the advancement of technology, it seems the local area network is here to stay and it is one of the vehicles for system integration which is taking place today and will continue. There is a definite trend towards user access to a wide variety of services and databases through the use of a desktop terminal such as Northern Telecom's "Displayphone" or Mitel's "Kontact" and this multi-function access can only be accomplished through the use of a LAN, a digital PABX, or a combination of both, depending on the user's needs. Thus, system integration is the path of the future that has its beginnings in the work place today.

5.0 OFFICE AUTOMATION

5.1 The Information Age

Presently, a remarkable change is occurring in the economic system as we are in a transitory phase between a manufacturing-based and an information-based economy. This transition is being fuelled by the tremendous advances in both the digital computer and the telecommunications industry. Both these realms of technology are concerned with the processing and movement of information and its interpretation and dissemination is becoming very important.

Information has very peculiar economic and other inherent properties which make it completely different from normal goods and services found in the economy. For example, information and communications are inextricably linked together. Information depreciates rapidly thus making timing important to the evaluation of information. Evaluation also depends on who has access to the information, how much other information he or she has access to, and his or her ability to process and to use it opportunely. The increased importance of information management and control is naturally finding its way to the office environment and is changing it drastically.

All offices have a great deal in common. They are used for the same kinds of activities - those related to the collection, storage, processing and distribution of information. The management of these activities is taking on a greater and greater importance to business and government for several reasons. The first relates to the increasingly competitive domestic and international market environment, which in turn will determine whether we have a

growing labour force. The second reason relates to the effectiveness of the office sector in general. In view of the increasing gains being made in the manufacturing and other industrial sectors of the economy, the office sector must make more effective use of its existing resources as the demand for overall productivity increases.

Currently, about 50 to 55 percent of Canada's labour force is employed in offices. Furthermore, in the near future, the percentage is expected to increase relative to employment in industry, and services. Capital investment per office worker, however, is low and office productivity growth is declining. These trends exact an economic price in terms of efficiency, growth and the ability of Canadian industry to compete in increasingly competitive international markets. Therefore, these factors of increased productivity, coupled with the dramatic advances being made in semiconductors, telecommunications, software applications and artificial intelligence, will accelerate the transition from the paper-based to the electronic office.

The age of the electronic office is indeed upon us. The trend is now towards improving the productivity of the office workplace through the use of electronics and integrated office systems. These integrated systems are the key to the increase of office productivity since they are designed to increase the number of tasks that can be performed in a finite period.

These systems are referred to as integrated because they serve to tie together various functions that were previously considered separate. For example, telephone, computer terminals, and word processing terminals are being combined so that one unit can perform these and many other functions (e.g. Mitel's Kontact). The level of integration extends still further as the one unit is able to access distributed printing devices, file servers, communication servers, and through established telecommunications networks, it can access remote data bases, as well as establishing data links with other similar units at various locations.

5.2 Teleconferencing

In the past several years, a tremendous concern has been shown towards the efficient use of our limited energy resources. Telecommunications has played a major role in this search for efficiency and one of its direct effects has been the development and implementation of teleconferencing throughout industry and government. Teleconferencing is further changing the way offices perform their daily tasks and its intimate connection with telecommunications is contributing to the automated office environment.

Teleconferencing is simply a unique gathering of people for business meetings using telecommunications services to bring together groups from diverse locations. It provides an effective alternative to spending large amounts of time and money to have business meeting participants gather at one location for face-to-face discussion.

Teleconferencing is not designed to replace the human interaction of the face-to-face meeting and discussion. However, it is designed to provide an effective way to have people communicate with each other on those occasions when a face-to-face encounter would not be necessary.

If teleconferencing is used as a daily communications tool, it enables managers to perform various facets of their job more quickly and efficiently. This allows decisions to be finalized in minutes, activities to be coordinated in a fraction of the usual time, and remote staff in geographically dispersed areas kept up-to-date on policies, decisions and strategies.

Teleconferencing equipment can be categorized under three main headings; (1) audio teleconferencing - which offers voice only conferencing, (2) "audio plus" teleconferencing - which offers voice plus visual information, and (3) video teleconferencing which offers voice plus full motion video services. (see exhibit 5.1) The visual information offered in "audio plus" services utilizes facsimile systems, electronic graphics, or slow-scan television systems. As development continues and the telephone and telecommunications networks become better equipped to transmit all types of graphic and pictorial information with improved resolution, this increased visual capability will greatly extend the role of teleconferencing in meeting information needs. Equipment such as freeze-frame, slow scan, facsimile machines, and electronic graphic systems are available today to perform the functions which slide projectors and chalk boards perform in regular meetings.

BELL CANADA

Equipment and Service Offerings

AUDIO CONFERENCING

Conference 100: an operator handled teleconference with all call participants contacted and bridged together by the conference operator.

Conference 200: a direct dial meet-me service which allows participants to dial directly in to the conference call with all parties being bridged manually by the conference operator.

Conference 300: a direct dial meet-me service with an automatic bridging capability. No operator assistance is involved.

Conference 100 and 200 services use the shared public network while Conference 300 calls are made via dedicated bridges which can be leased for a fixed monthly rate. This service is available 24 hours a day.

Add-on/Three-Way Calling: a telephone set/system feature which allows the user to add a third party to an established call.

Companion 2/Logic Handsfree: a desk top terminal for small group conferencing for meetings of up to four people per location.

Conference 2000: a table top terminal for large group meetings of up to 20 people per location in a conference room setting.

Equipment and Service Offerings are from Bell.

AUDIO PLUS CONFERENCING

Facsimile Systems: used in conjunction with audio conferencing, facsimile systems provide users with the capability to transmit documents over long distances which will be reproduced – much like photocopies – at remote locations within a matter of minutes or seconds. The material may be text, diagrams, engineering schematics, business forms, computer printouts, illustrations or virtually any information that is shown on paper.

Electronic Graphics: a variety of technologies allow the user to write, draw or create a picture which is electronically transmitted to the other conference locations. Material may be hand drawn on an electronic blackboard or tablet; or it may be generated from a computer graphics system.

Slow Scan or Freeze-Frame: these systems allow transmission over the telephone network of any still image that can be captured by a video camera (e.g. people, objects, charts or graphs). Transmission time can vary from 8.5 to 70 seconds depending on the resolution and operating mode desired.

Video Conferencing: full motion video provides the transmission of moving pictures and sound. Television cameras and monitors are required and transmission can be carried out using terrestrial or satellite facilities. □

EXHIBIT 5.1

Carrying the concept to its most advanced level, video teleconferencing allows participants to use full motion interactive communications. It enables users or participants to observe the reactions of everyone involved in the teleconference and it allows those participating to use charts, diagrams or slides.

5.3 Technical Aspects of Teleconferencing

Audio teleconferencing simply involves having several people communicate in a conference mode by establishing the proper bridging in the telephone network. Depending on the type and size of the gathering, telephone "hands free" units or individual microphones, voice switched or manually switched, could be used. For larger gatherings or more effective conferencing, integrated microphone units such as Bell's Conference 2000 table top terminal can be utilized.

Video teleconferencing is more complex as it requires the transmission of moving pictures and sound as in television. Television signals need a bandwidth of 6 MHz to depict images, colour, motion and sound. It is possible, however, to convey full motion colour video and audio within a bandwidth of only 1.5 Mbs by adopting information-compression techniques.

One example of a typical system is the NETEC-XI by NEC Inc. which is a digital TV terminal designed to transmit motion colour pictures using NTSC colour standards. The signal is converted to an 8-bit pulse modulated (PCM) code which is then band-compressed in the video encoder - resulting in a 2:1 improvement in motion encoding efficiency with full 525-line resolution. Output of the encoder is encrypted by

the video encryptor to assure privacy and an error correction coder is used to reduce line error effects. An audio analog-to-digital component converts the audio signals to an eight-bit PCM code. The digitized audio signal is multiplexed with the video signal and other data in the line interface after encryption in the audio encryptor. The unit also provides for T-1 line interfacing; the video, audio, and other data are combined into T-1 frame bits and transmitted over the wire pairs.

At the receiving end, a line interface unit strips the T-1 frame bits from the received data and separates the several signal types. Reconstruction of the video and the audio signal is accomplished via a process reversal.

Two way full-motion colour video is supported by most products that carry signals over terrestrial lines, satellite links, microwave links and coaxial cable.

5.4 Teleconferencing - Future Possibilities

As technology advances and the productive use of business time becomes more important, teleconferencing will retain its place in the day-to-day business environment.

Specifically, audio and "audio plus visual aid" teleconferencing will continue to grow in popularity due to their relative effectiveness.

Video teleconferencing is currently available in two forms: point-to-multipoint one way video and point-to-point two-way video teleconferencing. With the former case, two way audio is provided at each location to

allow for questions and answers at gatherings, e.g. for introduction of new products, annual meetings, news conferences or any form of mass information exchange. The latter case is typified by the familiar business meeting where two groups can see and hear simultaneously, present graphic materials and show products.

It seems as though point-to-multipoint video teleconferencing has had some impact on industry through its use in new product introduction. For example, if a large automaker unveils a new model, the introduction to the market is usually carried to several major cities thus involving considerable cost and repetitious presentation. With a point-to-multipoint video teleconferencing system, a tremendous expense is eliminated and an effective, accurate, enthusiastic show at each location is more likely since the introduction is carried out only once.

Point-to-point two-way teleconferencing is also quite attractive to the business environment; however, its tremendous cost puts it out of financial reach for all but the largest organizations. One way to circumvent this high cost is that the large organizations rent out their video teleconferencing facilities, when idle, to other companies on an hourly basis. This would tend to make the large firm's teleconferencing investment more productive.

The video teleconferencing market is expected to grow in the future. At the present time, a number of Canadian organizations have implemented freeze frame and full motion video. These include several hospitals, Bell Canada, IBM, the Royal Bank of Canada, the Canadian Government and the Government of Ontario.

5.5 Integration and the Advent of the Microprocessor

For readers having problems with some of the terms used in this section, a glossary of terms is provided in appendix I.

The integration of devices allows access to several functions and services. This is why the devices such as microcomputers, mainframes, telephones, printers, plotters, disk drives etc. are interconnected into a uniquely configured network that enables the user, sitting at a terminal at his or her desk, to perform a multitude of tasks rapidly and effectively. On this basis, networks of both the local area and wide area varieties are proliferating . This can be loosely referred to as system hardware integration or component integration since it involves connecting together different physical units.

Integration, however, is also taking place in the software so as to develop operating systems which allow proper interfacing and protocol-matching of the various devices. This is of vital importance since devices that perform different functions and are made by different manufacturers must be able to communicate with each other via some standard set of rules and operating conditions. These conditions must be supported by the manufacturers and incorporated by the system designers in order to operate the network. Currently the major interfacing standards, and indeed the major design standards, are being set by IBM. This is mainly due to IBM's enormous size, tremendous market share, and long standing presence as a major force in the technological environment.

In the past, IBM has dominated the computer industry and it has traditionally been the major supplier of large systems. With the advent of the microprocessor and the microcomputer, this dominance in the high tech office systems area has been challenged and has forced IBM to develop new areas of technology specifically in the microcomputer field. Apple Computer Inc. and Commodore Business Machines Inc. have established strong markets for their microcomputer products in both the consumer and business environments and in doing so, they have virtually revolutionized the way people perceive computing. This has led to the development of microcomputer systems by other firms such as Radioshack, Hewlett Packard, Wang, Xerox, Sperry and, of course IBM.

In the past computing was done by only large organizations such as banks, governments, and multinationals and the heart of the system was usually a large mainframe computer (usually IBM). However, with the emergence of the microcomputer, people became aware of the power and versatility of these units that were relatively small and much less expensive. They also realized that these computers would have applications in environments other than the large organizations and they could have numerous uses.

The development of the microcomputer, now commonly referred to as the personal computer, professional computer or simply the PC, is the "Second Industrial Revolution" since it is moving all segments of society straight into the Information Age. The availability of tremendous computing power at a very reasonable price (and one that is falling steadily) has affected the North American society as no other product did before and nowhere is it felt more than in the office environment.

In an era where human interaction can take place at tremendously rapid speeds, control and availability of information that is vital to daily operation and decision making is of the utmost importance. In this type of environment, the microcomputer has emerged as a vital tool in supporting a large number of business applications and its functionality is expected to increase.

5.6 Advances in Microcomputer and Related Technologies

In the past five years, the use of microcomputers in industry and business has increased tremendously primarily due to advances in microcomputers themselves. They have undergone tremendous evolution in practically every aspect of their design. Today's models have more memory, faster processors with larger capacities, screens with a multitude of colours and much higher resolution, more versatile operating systems, screen sensing input devices and a list of applications and software packages that perform a phenomenal number of tasks. The following sections briefly consider some of the major developments in the microcomputer and some of the unique features in today's office environments.

i) Memory

Computer memory size has been increasing constantly. Early units on the market had approximately 4000 Bytes of user accessible memory. The basic unit of computer information is the "bit" which is a contraction of "BInary digiT" - computers use only two digits 0 and 1. Eight bits form a byte and sixteen bits form a "word".

Memory size is usually indicated in kilobytes (e.g. 4K) or megabites (M) and 1K of memory is enough to hold about half a normal typewritten page of data.

Computer memory has two major types: read-only memory (ROM) and random-access memory (RAM). ROM refers to memory that can only be read and cannot be changed once it has been put in place by the manufacturer. The Central Processing Unit (CPU), which is the actual brain of the microcomputer, can find all of its basic operating instructions in the ROM.

RAM, on the other hand, is "volatile" memory since it can be overwritten and it turns blank once the machine is turned off. RAM can be considered as user memory since that is where any data the user generates (e.g. programs, files, etc.) or loads from an external source (e.g. a floppy disk), is stored.

Most microcomputers on the market today have at least 64K of RAM (some have 128K, a few 256K) and many are memory expandable through the addition of further memory cards. Also, new microcomputers have more user software in their ROMs. Since ROM contents can be executed at twice the speed of RAM, it increases the operating efficiency of the microcomputer.

Another type of memory that is an integral part of microcomputers is the peripheral memory provided by disk drives. Disks are either hard or the floppy type. Floppy disks are made of flexible material that is able to store information. For data retrieval, the disk is rotated within the disk drive and information is transmitted via read/write heads. The disk spins inside its cardboard envelope at about 300 revolutions per minute. The name floppy disk usually refers to an 8 inch diameter disk but it has come to include 5 1/4 and 3 inch disks as well.

The hard disk, on the other hand, is made of rigid ceramic-like material with magnetic coating. They are generally encased in some protective cover and kept in a sheltered environment thereby preventing damage from dust, smoke, and other foreign materials. Hard disks are generally used for storage of large amounts of data and their capacity varies from 2 to 10 Megabytes, and still larger for some data base and file-server applications.

ii) Microprocessors

The heart of the microcomputer is the microprocessor which is an integrated circuit (IC) that contains most of the elements of a computer all enclosed in one package. The microprocessor usually contains the arithmetic-logic unit (ALU), various buffers, counters, registers and pointers so as to be able to execute the programmed instructions.

Microprocessors generally perform the same functions regardless of manufacturers; however they differ in internal chip design, ROM allocation, and processing speed. There are different families of chips such as the 6800, 6809, and 68000 by Motorola and the 8080 and 8088 by Intel. Microprocessors have up until now been predominantly of the 8-bit variety; that is, they process data 8 bits at a time. However, recently both 16 and 32 bit processors have come on the market. These processors have tremendous computing power and they operate faster (examples of 16 bit machines: IBM PC, HP 150, Apple Macintosh - Macintosh also comes in a 32 bit super micro model). The 32-bit machines are referred to as supermicrocomputers because they have the computing power of a much larger minicomputer.

Some microcomputers on the market contain several microprocessors of different types thereby enabling the machine to be much more versatile in running software. These systems are often designed with parallel operating structures for the different processors thus making the operation a tremendously complex process. These designs are often experimented with due to the extremely low cost of the microprocessor chips. For example, a M6800 which is the heart of the Apple's 32-bit Macintosh sells for approximately $49.95 in the U.S.

iii)The Display Screen

Many changes have occurred in the design and operation of display screens - both in what you see on the screen and how you can go about altering it. Early monitors were simply 40 x 25 column monochrome screens that enabled the user to see what he or she had input via the keyboard and to receive output.

The microprocessor considers the display screen as simply another set of locations in memory (usually referred to as screen memory) that serve as an output device to the user. Generally speaking, whenever the processor generates any type of output it can be sent to either the screen, a printer, a disk drive, or sometimes all three. Display screens are no longer monochrome - indeed many micros have the ability to carry eight and some specialized graphics terminals (e.g. IBM 3270 XG) up to sixteen different colours.

Monochrome screens are rarely black and white as they have been replaced by either green or more recently amber coloured screens which tend to cause less eyestrain over long periods of use. The resolution on these screens has also increased allowing for more versatile graphics. Display screens are generally 80 x 25 columns with specialized graphics terminals having still higher resolution (e.g. IBM 3270XG).

The physical aspects of display screens are also undergoing a certain evolution. Until now, screens have been basic cathode ray tubes (CRT's) which were commonly used in television sets long before the advent of the microcomputer. However new types known as plasma screens are currently on the market. These are much less bulky than traditional CRT's because they work on different principles. CRT's are basically gas filled tubes with phosphor coating at one end and an electron gun at the other. The gun emits electrons which can be deflected by surrounding

fields. These deflected electrons cause the phosphor surface to glow at the point it is struck by the electrons. This glowing creates the image that a viewer sees on a TV set or a microcomputer screen. Plasma screens do not employ the guns to cause the glow. Instead, a layer of plasma controlled by an electronic grid is placed near the phosphor. This excites the phosphor causing it to glow at certain controllable points on the grid. Thus the same glowing effect can be achieved without using a bulky tube and an electron gun. Plasma screens are becoming quite popular because they are less bulky and they operate on considerably less power than conventional CRT's.

Screen usage is also undergoing considerable change. In the past, the entire screen was used for one operation at a time. Now, however, software packages and operating systems are allowing the screen to be divided into "windows" or sections, portions of which are always seen. This is analogous to overlapping sheets of paper on a desk. The window the user wishes to work in is expanded to take up the entire screen. This is analogous to pulling a piece of paper off one of many stacks of paper on the desk.

iv) Software

The amount of software available for microcomputers today is astonishing. This cottage industry (software development) has grown at an incredible rate and it is expected to keep on expanding as illustrated in Appendix II. For example, Apple Computer Inc. estimates there are more than 10,000 different application software packages that run on its machines.

Business packages are all unique, however they do perform many of the same tasks. These often include data base creation and management, word processing, report writing, spreadsheets, graphs and preparation of other plotted figures. Wordprocessing is a very popular application of micros. This has sparked considerable competition for the dedicated wordprocessor manufacturers such as AES and MICOM. Report writing usually incorporates wordprocessing characteristics with integrated graphics capabilities for proper formatting. It also incorporates special features such as spelling checks with expandable dictionaries that can accommodate words commonly used in particular disciplines or professions. Spreadsheet features are extremely useful for budgeting or accounting since it allows you to create customized columns and rows of figures in variable format. Finally, the graphics capabilities available through the current software are very versatile and effective. Multicoloured pie charts, bar graphs, line graphs and other figures which are traditionally used to convey information, can be constructed easily and produced with comparatively little effort on the part of the user. These figures are often found in business environments since they tend to convey information far more effectively than simply tables of numbers.

v) User Control

The keyboard has remained an important part of any microcomputer; however, its function as the sole method of human input has been eroded by several new technologies.

Cursor movement has been greatly increased through the use of a "joystick", a small device that can be added on to a microcomputer. It is a lever mounted on a ball thereby allowing 360^{o} swivel movement which corresponds to 360^{o} movement of the cursor on the screen. Joysticks have found numerous applications in games programs and simulations involving movement of an object through space.

Further advancements have been made in the way a user indicates to the computer what he or she wants it to do. A new product appearing on the market is the "mouse" (Exhibit 5.2) which is a hand held device in a small box that can translate arm movements into commands which in turn are monitored on the computer screen. The mouse contains a rotating ball and optical sensors which translate its movements to the microcomputer's screen pointer with pinpoint accuracy. It is usually operated by sliding a small box along a tablet, roughly the same size as the screen, usually marked off as a large grid which can be sensed by the optical sensors in the mouse. It also has a button on top of it that can be depressed by the user to let the microprocessor know that something should be done at the spot that is indicated by the screen pointer. Thus the mouse replaces type-in commands with a form of communication that the user is very familiar with - pointing.

The mouse commonly points at symbols called "icons" (Exhibit 5.3) which usually represent different functions that the computer will perform or else it can point at key words that appear on the screen as is

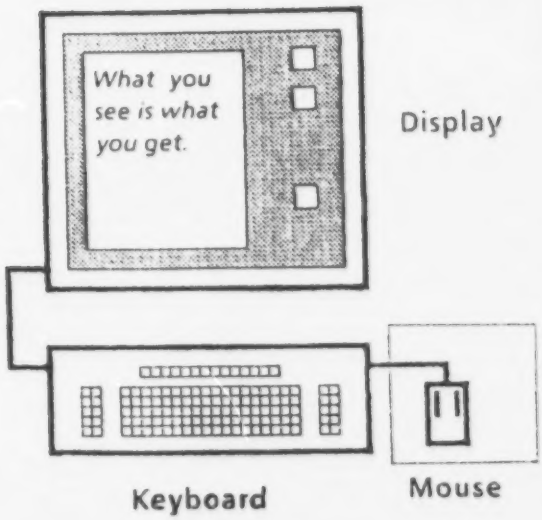
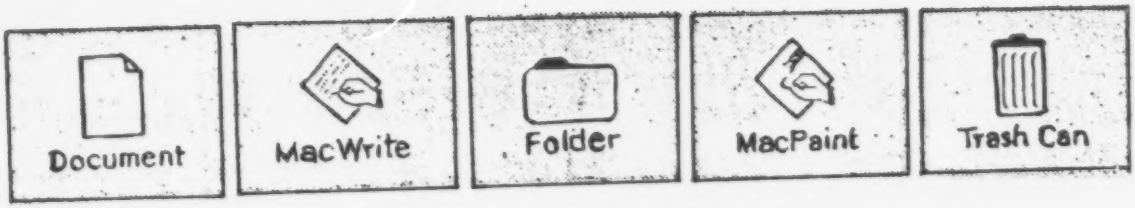


EXHIBIT 5.2


Document
MacWrite
Folder
MacPaint
Trash Can

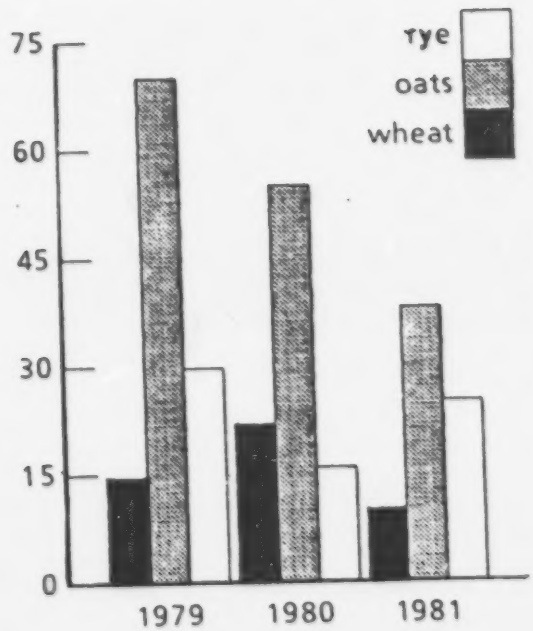

75
60
45
30
15
0
rye
oats
wheat
1979
1980
1981

EXHIBIT 5.3

the case with pull-down menus. For example, if the user wished to see the main menu of a particular package and "main" was one of the key words appearing on the screen, he or she would use the mouse to move the cursor on top of "main" and then press the switch on top of the mouse. This would cause the main menu to be put on the screen or "pulled down". Another example would be if the user wished to send output to file, he or she would look for an icon, which may be for example, a file folder, and move the cursor on top of the icon. On reaching that location on the screen and depressing the switch on the mouse, the desired output would be filed away in memory.

Further developments include the use of a light pen which the user manipulates by touching the screen at a desired point on pressing a switch to indicate the location on the screen to the microprocessor. Use of a light pen is predominantly found in interactive graphics systems.

Hewlett Packard have taken the mouse concept on to the screen and refined it to a state-of-the-art system. They have developed HP-150 "Touchscreen" personal computer which operates by having the user touch the screen on appropriate icons or key words to perform a function. This is a big step towards easier use of microcomputers. Typing, which used to be the only way to input, is slowly being surpassed by more sophisticated and simple systems such as the mouse and the touchscreen. It can be seen from the above descriptions how the operation of a microcomputer has evolved tremendously from simply typing data and commands on a keyboard.

5.7 Executive Use Of Microcomputers

With microcomputer operation becoming easier, more and more people within business organizations are using them in everyday. This not only includes secretarial and support staff, but also managers and executives. This increased use up the corporate ladder is improving the decision making capabilities of management because it allows managers faster access to more information. From initial use by secretaries and clerical staff, microcomputer use has extended all the way up to top level executives.

With emphasis on quick information retrieval and gathering, microcomputer developments such as the mouse and the touchscreen have been ideally suited to executives since they can use the systems without having to do a lot of typing. This is a major advancement and has reduced the resistance of executives and managers to using microcomputers in their daily routines.

Additional advantages such as increased computing power and lower prices are turning microcomputers into corporate workhorses enabling managers to link with the home office while on business trips or to communicate with branch offices. A recent entry that has contributed to increased microcomputer use in a variety of environments is the portable microcomputer. This is much smaller than the traditional desktop micro as it consists of a small eight to ten line LCD display. Portable micros usually weigh about five to ten pounds and contain 8K to 128K of RAM depending upon the model and the manufacturer. Several popular models are currently on the market, Hewlett-Packard's Portable, Radioshack's TRS-80 Model 100, and Sharp's PC-5000 (known as the Commuter Computer).

These units are very useful for business people who tend to be on the move a great deal since they can be interfaced to the main systems residing at the user's office. These portables are much smaller than the "transportables" introduced by IBM, Texas Instruments, Zenith and others. A transportable computer is really a desktop computer with a handle on it that can be carried from the office to the car. Portables, on the other hand, are truly portable since they are small enough to fit in a briefcase, and run on batteries.

Whether portables or transportables (commonly referred to as "luggables"), there is a definite trend towards usage of microcomputers in environments other than the office. Their use would greatly increase the business person's productivity since the time saved from travelling could be put to other use.

5.8 Office Automation - Starting Today and Continuing Tomorrow

Office automation will continue to change the way office activities are carried out. As microcomputers become faster, more powerful, and easier to use, their integration into the day-to-day office practices will speed the process of advancing our society to an age where the access, creation, and dissemination of information, will be paramount.

In the office environment higher computer usage combined with advanced electronic communication will lead towards a more "automated" office in the sense that more functions can be carried out electronically and there will be much less paper flow. Indeed, some theorists predict a "paperless" office with all correspondence and data interaction carried out via computer terminal. The

computer, with its processing and data handling capabilities, will be apparent at all levels of the corporate hierarchy. Its use will facilitate desired increases in office productivity thereby making it cost effective. It is also compatible with the increased trend towards automation and computerization taking place in the manufacturing sector of the economy.

The trend towards increased automation in the office environment will cause significant alterations in the functions performed today. However, in order to avoid long term economic instability, these alterations will result in people shifting to new functions, learning new skills, and generally participating in the increased volume of operation that will result due to the increased capability of the automated systems. This metamorphosis is a long term occurence that will hopefully result in a better and more efficient use and allocation of scarce resources thereby facilitating a better standard of living.

Governments, at all levels, will have key roles to play in this metamorphosis of society and technology to ensure that the transition and long term stabilization can occur in an equitable and effective manner.

APPENDIX I

GLOSSARY OF COMPUTER TERMS

ACCESS TIME:

The time it takes a computer to deliver information requested by a user.

ANALOG:

The representation of numerical quantities by means of physical variables such as voltage, current or resistance.

ASCII:

An acronym for American Standard Code for Information Interchange. It is an international standard that defines how characters are represented in the computer's storage. Each combination of the eight different bits in a byte, represents a unique character. Each is assigned a number between 0 and 127.

BAUD:

A measurement of communications speed between devices. A baud usually - but not always - refers to bits transmitted per second. When divided by 10, a baud usually represents the number of characters transmitted per second.

BIT:

A contraction of binary digit. A bit is the smallest unit of information in a digital computer.

BOOT or bootstrap:

The loading and execution of instructions, which are then used to load the rest of a computer program.

BUFFER:

A temporary holding location for computer data until processed by another device. It is needed because the data can flow at different rates between a computer and its peripherals.

BUS:

A set of electrical circuits into which other circuit boards can be plugged. A high speed electronic highway.

BYTE:

A group of adjacent bits that represent a single unit of information.

CPU:

Central processing unit. The part of the computer containing the circuits that interpret and execute instructions to the computer.

CHIP:

A piece of silicon the size of fingernail, upon which an integrated circuit is etched. The circuit contains logical patterns of computer processing. A number of chips are cut out of a larger wafer.

CORE:

A piece of magnetic material that contains information inside the computer. The term has come to refer to the internal semiconductor memory of the computer.

CP/M:

Control program for microprocessors. A common disc operating system for microcomputers developed by Digital Research Inc. of Pacific Grove, California.

CURSOR:

An indicator on a video display screen that shows where the next character will be typed.

DIRECTORY:

A list of the locations of computer files in the storage medium.

DISC, diskette:

A circular plate that has magnetic material on both sides to store information. For data retrieval, the disc is rotated within the computer's disc drive. Material is transferred between the disc drive and the main computer by one or more heads.

FILE:

A collection of similar data, or a group of related records, treated as a unit.

FIRMWARE:

A computer program permanently fixed inside a chip, which remains intact even if power is lost. Many routine operations are encoded into the machine to improve efficiency and relieve programmers of repititive tasks.

FLOPPY DISC:

A disc made of flexible, magnetic material and housed in a cardboard envelope. The disc spins inside this jacket at about 300 revolutions a minute. Although the names are often interchanged, a floppy disc, usually refers to the eight-inch-diameter disc, while the 5 1/4-inch variety is a mini-floppy.

GIGABYTE:

A billion bytes. (Actually, 2 to the 36th power, which is 1,073,741,824 bytes).

HARD DISC:

A disc made of rigid ceramic-like material with a magnetic coating. It is kept in a sheltered environment to prevent damage from dust, smoke and pollutants.

HEAD:

The small electromagnetic device inside a disc drive that reads, records and erases data on the disc.

INTERFACE:

The connection between two devices, such as the computer and the keyboard, or the conventions for passing control and data between two programs.

INTERPRETER:

A translator for a programming language that executes the program by converting each command into instructions the computer can perform. This permits easier program development, but slows the speed of operation. See compiler.

K or KB:

An abbreviation for a kilobyte, which is 1,024 bytes. This is about half of a normal typewritten page, so 64K would be enough memory to store about 32 typed pages.

LOCAL AREA NETWORK:

A communications system that allows a number of information processing devices to link up with each other for a limited distance, such as within a college campus.

MAIN MEMORY:

The computer's internal memory, which is also known as RAM or core. It is volatile, which means the contents are destroyed if power is lost.

MASS STORAGE:

A non-volatile, mechanical memory device, such as magnetic tape, disc or punch cards.

MB or M:

A megabyte, consisting of a million (actually 2 to the 20th power of 1,048,576) bytes.

MENU-DRIVEN:

Software that guides the microcomputer user by presenting a number of alternative functions from which to choose.

MICROCOMPUTER:

A computer based on a microprocessor, usually referring to machines costing less than $20,000.

MICROPROCESSOR:

A computer on a chip. It is an integrated circuit containing most of the elements of a computer.

MODEM:

A contraction of modulator-demodulator, a device that translates computer data into pulses that can be transmitted over telephone lines or optical cables. See acoustic coupler.

MOUSE:

A hand-held device that translates arm movements into commands on the computer screen.

MULTI-TASKING:

The ability of the computer to do more than one job or program at the same time.

OEM:

An acronym for original equipment manufacturer. It refers to companies that purchase components to add to products before distributing them.

OPERATING SYSTEM:

The set of programs that make it easier to operate the computer. It does such tasks as input-output between the computer and its peripherals, or accepting and interpreting information entered through the keyboard.

PERIPHERAL:

A device that attaches to the computer, such as a disc drive, terminal or printer.

RAM:

An acronym for random access memory. RAM is also known as math or internal memory. It is memory that can be altered by writing over previous contents. RAM is volatile and the contents are destroyed if power is lost.

ROM:

An acronym for read-only memory. ROM is a form of internal memory or chip on which commonly used programs are permanently placed to be read by the computer.

STAND-ALONE:

A device that is self-contained, not dependent on another unit for memory or processing.

TRANSPORTABLE:

A microcomputer that can be carried by hand, but weighs more than the more compact portable units. Also called "luggables."

USER-FRIENDLY:

A machine that is simple to operate and easily understood by the average user.

UTILITY:

A program used to help operate the computer. Typical utilities are sorting routines or file conversion programs.

VIRTUAL MEMORY:

This refers to the exchange of portions or pages of internal memory with the disc storage unit. Virtual memory permits the use of programs that are larger than the internal memory.

WINDOWS:

Software that allows the user to see several functions at once on a single screen. The screen is divided into partitions.

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APPENDIX II

CANADIAN INFORMATION PROCESSING INDUSTRY REVENUE FORECAST TO 1985

($million - includes exports)

	Actual	Forecast	
	1983	1984	1985
Hardware	4890	5820	6925
Annual Growth (%)	18	19	19
Services:			
Software			
Total software	825	1060	1385
Annual Growth (%)	29	28	31
Consulting, education, misc.	380	450	525
Annual growth (%)	23	18	17
Processing services	755	800	840
Annual growth (%)	8	6	5
Total services	1960	2310	2750
Annual growth	19	18	19
Total revenues	6850	8130	9675
Annual growth (%)	18	19	19

Source: Compiled by Evans Research Corp.